

ANNUAL  
REPORT  
**2023**



**INSTITUTO DE  
FÍSICA  
CORPUSCULAR**

**IFIC**

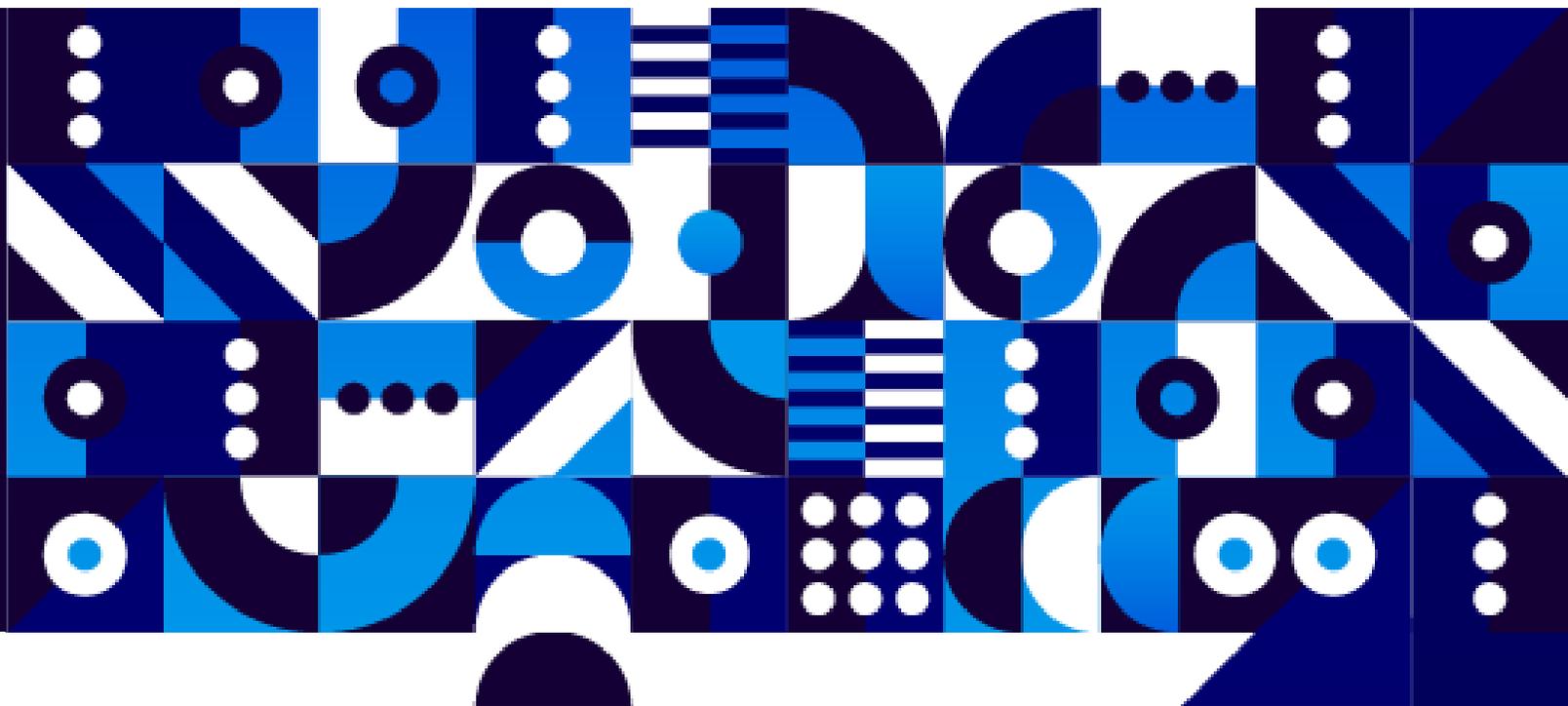
INSTITUT DE FÍSICA  
CORPUSCULAR

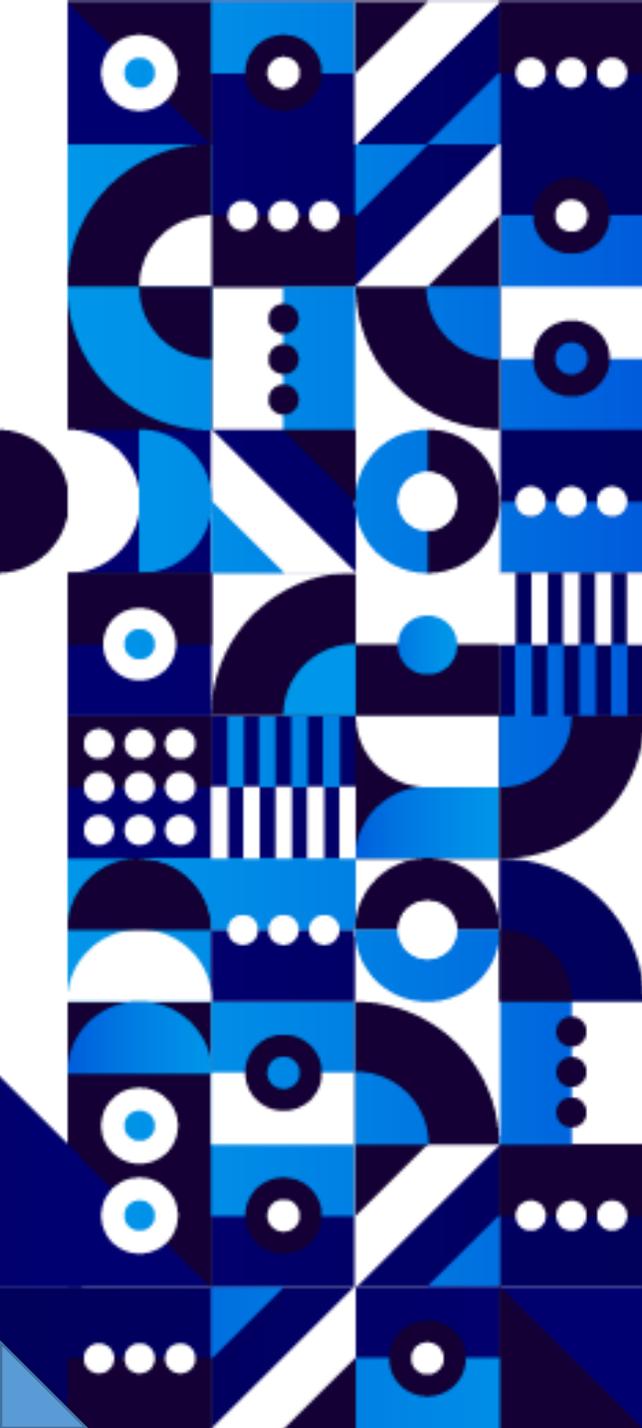


VNIVERSITAT  
DE VALÈNCIA



**CSIC**  
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS





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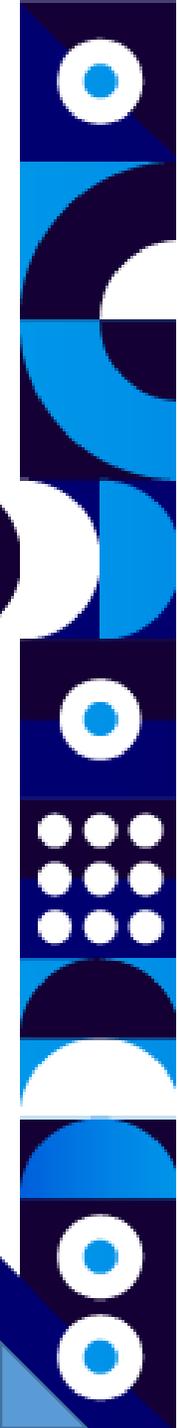


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WELCOME





# 1 LETTER FROM THE DIRECTOR

Español

**E**ste año ha sido un año de intensa actividad científica en el IFIC. Es imposible resumir en dos páginas todos los resultados de nuestra investigación, por lo que os invito a conocerlos con más detalle leyendo esta memoria. Solo adelanto que abarcan un amplio espectro: desde la observación de los sucesos con cuatro quarks top, la partícula más pesada de las conocidas, en el experimento ATLAS, hasta la obtención de una ayuda Prueba de Concepto del Consejo Europeo de Investigación (ERC) para desarrollar dispositivos que monitoricen la cirugía y el tratamiento contra el cáncer, por citar dos ejemplos.

Empezamos 2023 con las Jornadas tecnológicas del IFIC, que se realizan cada dos años, y a lo largo de los siguientes meses continuamos la serie de Jornadas científicas iniciada en 2021 con las correspondientes a las líneas L4 “Baryogenesis, dark matter and cosmic messengers”, L6 “The synthesis of nuclei” y L8 “Advanced Instrumentation &

Computing for Societal Challenges”.

Dos profesoras de investigación del IFIC han asumido en 2023 importantes responsabilidades: Berta Rubio ha sido elegida como presidenta del Consejo NUSTAR, del que ya era copresidenta desde 2020. NUSTAR es una institución que representa a la comunidad internacional de Estructura, Astrofísica y Reacciones Nucleares. Y María José Costa es la nueva directora del CPAN (Centro de Partículas, Astropartículas y Nuclear), que surgió como un proyecto Consolider-Ingenio 2010 con el objetivo de estimular la cooperación entre los grupos españoles expertos en física de partículas, astropartículas y nuclear.

La investigación de alta calidad realizada en el IFIC ha recibido importantes reconocimientos en 2023: el catedrático de la Universitat de València Eulogio Oset ha sido galardonado con la medalla de la Real Sociedad Española de Física por su “excepcional carrera científica en el campo de la física teórica, lo que le ha convertido en una referencia en física nuclear”; Diego Real ha recibido el premio Nikola Tesla del Colegio Oficial de Ingenieros Técnicos Industriales de Valencia en la categoría ‘Trayectoria Profesional Prestigiosa’; el proyecto HYBRIMS (Hybrid Imaging Systems), promovido por el investigador del IFIC Luis Caballero, que desarrolla dispositivos médicos para el diagnóstico preciso del cáncer, ha resultado galardonado en la categoría Proyecto de Mayor Impacto por la asociación Seniors

Españoles para la Cooperación Técnica (SECOT) y doce investigadores del IFIC han resultado beneficiarios en la primera convocatoria de Ayudas para la Consolidación Investigadora lanzada por la Agencia Estatal de Investigación del Ministerio de Ciencia e Innovación.

También las tesis desarrolladas en el IFIC han recibido numerosos premios: Pablo Villanueva y Adrià Delhom i Latorre sendos premios del CSIC a las mejores Tesis Doctorales, Miguel García Folgado y Fernando Romero López los premios extraordinarios de Doctorado 2022-23 de la Universitat de València y la tesis de Mario Reig ha sido elegida entre las dieciséis mejores tesis por la Real Academia de Doctores de España.

Dentro del Proyecto Meitner, la iniciativa de divulgación sobre ciencia y género del Instituto de Física Corpuscular que cuenta con la colaboración de la Fundación Española para la Ciencia y la Tecnología - Ministerio de Ciencia e Innovación, se han llevado a cabo en 2023 varias actividades: las Jornadas de Ciencia y Género, coordinadas con CEFIRE, enfocadas para profesores de enseñanza secundaria; la representación de la obra teatral que lleva a escena la vida de Lise Meitner, pionera de la física nuclear olvidada por el comité del Premio Nobel; la III Edición del concurso multidisciplinar Express-Arte ConCiencia, dirigido al alumnado de secundaria y ciclos formativos, y la exposición “Pioneras”, que ha reunido las obras ganadoras y seleccionadas de las tres

ediciones celebradas de dicho concurso, y cuenta además con una colección de obras propias de la artista italiana Mónica Mura.

Este año también se ha celebrado en el IFIC la presentación del Plan Complementario de Astrofísica y Física de Altas Energías en la Comunitat Valenciana, coordinado por el investigador del IFIC Carlos Lacasta, con la participación de la consellera de Innovación, Universidades, Ciencia y Sociedad Digital, Josefina Bueno, entre otras autoridades. Además recibimos la visita de la presidenta del CSIC, Eloísa del Pino, y de la rectora de la Universitat de València, María Vicenta Mestre, así como de la secretaria autonómica de Universidades, M<sup>a</sup> Esther Gómez y del director general de Ciencia e Investigación, Rafael Sebastián.

En 2023 hubo una renovación de la dirección del IFIC, por lo que agradezco a todo el equipo directivo, la vicedirectora saliente, Berta Rubio, el vicedirector entrante, Sergio Pastor, y los dos vicedirectores que continúan, Michel Sorel y José Enrique García Navarro, su tiempo, implicación y apoyo.

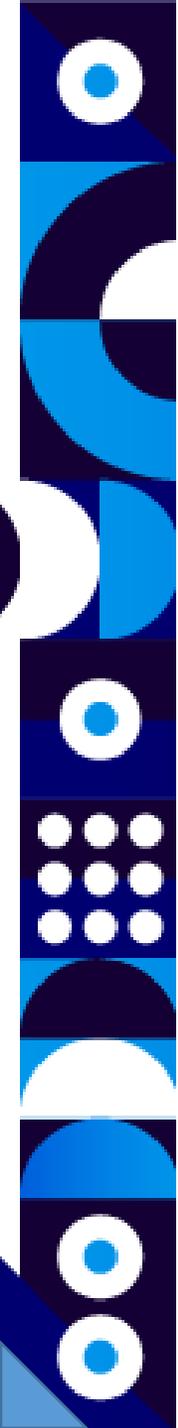
Para terminar, quiero reconocer el trabajo y dedicación de los miembros del IFIC, tanto el personal docente e investigador como el personal técnico, de administración y comunicación. Gracias a ellos han sido posibles las numerosas actividades descritas en esta memoria, y todos son necesarios para que podamos mantener nuestro liderazgo internacional.



**N**uria Rius

Directora del IFIC

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# 1 LETTER FROM THE

## DIRECTOR

### Valencià

enguany ha sigut un any d'intensa activitat científica en l'IFIC. És impossible resumir en dues pàgines tots els resultats de la nostra investigació, per la qual cosa us convida a conèixer-los amb més detall llegint aquesta memòria. Només avance que abasten un ampli espectre: des de l'observació dels successos amb quatre quarks top, la partícula més pesada de les conegudes, en l'experiment ATLES, fins a l'obtenció d'una ajuda Prova de Concepte del Consell Europeu d'Investigació (ERC) per a desenvolupar dispositius que monitoren la cirurgia i el tractament contra el càncer, per citar dos exemples.

Vam començar 2023 amb les Jornades tecnològiques de l'IFIC, que es realitzen cada dos anys, i al llarg dels següents mesos vam continuar la sèrie de Jornades científiques iniciada en 2021 amb les corresponents a les línies L4 "Baryogenesis, dark matter and cosmic messengers", L6 "The synthesis of nuclei" i L8 "Advanced Instrumentation & Computing for Societal Challenges".

Dues professores d'investigació de l'IFIC han assumit en 2023 importants responsabilitats:

Berta Rubio ha sigut elegida com a presidenta del Consell NUSTAR, del qual ja era copresidenta des de 2020. NUSTAR és una institució que representa a la comunitat internacional d'Estructura, Astrofísica i Reaccions Nuclears. María José Costa és la nova directora del CPAN (Centre de Partícules, Astropartícules i Nuclear), que va sorgir com un projecte Consolider-Enginy 2010 amb l'objectiu d'estimular la cooperació entre els grups espanyols experts en física de partícules, astropartícules i nuclear.

La investigació d'alta qualitat realitzada en l'IFIC ha rebut importants reconeixements en 2023: el catedràtic de la Universitat de València Eulogio Oset ha sigut guardonat amb la medalla de la Reial Societat Espanyola de Física per la seua "excepcional carrera científica en el camp de la física teòrica, la qual cosa li ha convertit en una referència en física nuclear"; Diego Real ha rebut el premi Nikola Tesla del Col·legi Oficial d'Enginyers Tècnics Industrials de València en la categoria 'Trajectòria Professional Prestigiosa'; el projecte HYBRIMS (Hybrid Imaging Systems), promogut per l'investigador de l'IFIC Luis Caballero, que desenvolupa dispositius mèdics per al diagnòstic precís del càncer, ha resultat guardonat en la categoria Projecte de Major Impacte per l'associació Sèniors Espanyols per a la Cooperació Tècnica (SECOT) i dotze investigadors de l'IFIC han resultat beneficiaris en la primera convocatòria d'Ajudes per a la Consolidació Investigadora llançada per l'Agència Estatal d'Investigació del Ministeri de Ciència i

Innovació.

També les tesis desenvolupades en l'IFIC han rebut nombrosos premis: Pablo Villanueva i Adrià Delhom i Latorre els premis del CSIC a les millors Tesis Doctorals, Miguel García Folgado i Fernando Romero López els premis extraordinaris de Doctorat 2022-23 de la Universitat de València i la tesi de Mario Reig ha sigut triada entre les setze millors tesis per la Reial Acadèmia de Doctors d'Espanya.

Dins del Projecte Meitner, la iniciativa de divulgació sobre ciència i gènere de l'Institut de Física Corpuscular que compta amb la col·laboració de la Fundació Espanyola per a la Ciència i la Tecnologia - Ministeri de Ciència i Innovació, s'han dut a terme en 2023 diverses activitats: les Jornades de Ciència i Gènere, coordinades amb CEFIRE, enfocades per a professors d'ensenyament secundari; la representació de l'obra teatral que porta a escena la vida de Lise Meitner, pionera de la física nuclear oblidada pel comitè del Premi Nobel; la III Edició del concurs multidisciplinari Express-Art ConCiència, dirigit a l'alumnat de secundària i cicles formatius, i l'exposició "Pioneres", que ha reunit les obres guanyadores i seleccionades de les tres edicions celebrades d'aquest concurs, i compta a més amb una col·lecció d'obres pròpies de l'artista italiana Mónica Mura.

Enguany també s'ha celebrat en l'IFIC la presentació del Pla Complementari d'Astrofísica i Física d'Altes Energies en la Comunitat Valenciana, coordinat per

l'investigador de l'IFIC Carlos Lacasta, amb la participació de la consellera d'Innovació, Universitats, Ciència i Societat Digital, Josefina Bueno, entre altres autoritats. A més rebem la visita de la presidenta del CSIC, Eloísa del Pino, i de la rectora de la Universitat de València, María Vicenta Mestre, així com de la secretària autonòmica d'Universitats, M<sup>a</sup> Esther Gómez i del director general de Ciència i Investigació, Rafael Sebastián.

En 2023 va haver-hi una renovació de la direcció de l'IFIC, per la qual cosa agraiïsc a tot l'equip directiu, la vicedirectora sortint, Berta Rubio, el vicedirector entrant, Sergio Pastor, i els dos vicedirectors que continuen, Michel Sorel i José Enrique García Navarro, el seu temps, implicació i suport.

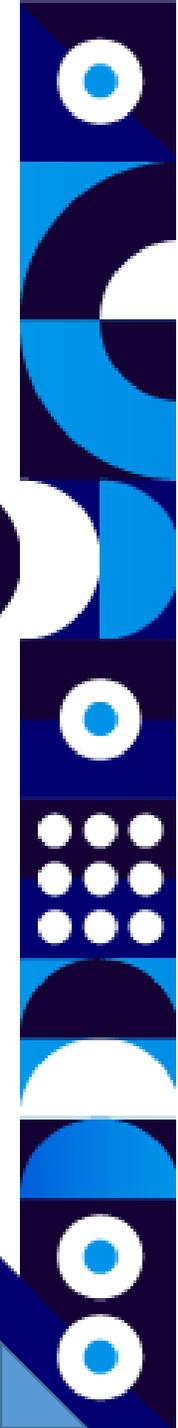
Per a acabar, vull reconèixer el treball i dedicació dels membres de l'IFIC, tant el personal docent i investigador com el personal tècnic, d'administració i comunicació. Gràcies a ells han sigut possibles les nombroses activitats descrites en aquesta memòria, i tots són necessaris perquè puguem mantindre el nostre lideratge internacional.



**N**uria Rius

Directora de l'IFIC

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# 1 LETTER FROM THE DIRECTOR

English

This year has been a year of intense scientific activity at IFIC. It is impossible to summarize all the results of our research in two pages, so I invite you to learn more about them by reading this report. I can only say that they cover a wide spectrum: from the observation of events with four top quarks, the heaviest known particle, in the ATLAS experiment, to obtaining a Proof of Concept grant from the European Research Council (ERC) to develop devices to monitor surgery and cancer treatment, to cite two examples.

We begin 2023 with IFIC's Technology Days, which are held every two years, and over the following months we continue the series of Scientific Workshops started in 2021 with those corresponding to lines L4 "Baryogenesis, dark matter and cosmic messengers", L6 "The synthesis of nuclei" and L8 "Advanced Instrumentation & Computing for Societal Challenges".

Two IFIC research professors have taken on important responsibilities in 2023: Berta Rubio

has been elected as president of the NUSTAR Council, of which she was already co-president since 2020. NUSTAR is an institution that represents the international community of Nuclear Structure, Astrophysics and Reactions. And María José Costa is the new director of CPAN (Center for Particle, Astroparticle and Nuclear Physics), which emerged as a Consolider-Ingenio 2010 project with the aim of stimulating cooperation between Spanish groups with expertise in these domains.

The high-quality research carried out at IFIC has received important recognition in 2023: the professor at the University of Valencia Eulogio Oset has been awarded the medal of the Royal Spanish Society of Physics for his "exceptional scientific career in the field of theoretical physics, which has made him a reference in nuclear physics"; Diego Real has received the Nikola Tesla award from the Official College of Industrial Technical Engineers of Valencia in the 'Prestigious Professional Career' category; the HYBRIMS (Hybrid Imaging Systems) project, promoted by IFIC researcher Luis Caballero, which develops medical devices for the precise diagnosis of cancer, has been awarded in the category of Greatest Impact Project by the association Spanish Seniors for Technical Cooperation (SECOT) and twelve IFIC researchers have been beneficiaries in the first call for Grants for Research Consolidation launched by the State Research Agency of the Ministry of Science and Innovation.

Theses developed at IFIC have also received

numerous awards: Pablo Villanueva and Adrià Delhom i Latorre have received the CSIC awards for the best Doctoral Theses, Miguel García Folgado and Fernando Romero López have received the extraordinary Doctorate awards 2022-23 from the University of Valencia, and Mario Reig's thesis has been chosen among the sixteen best theses by the Royal Academy of Doctors of Spain.

Within the Meitner Project, IFIC's science and gender outreach initiative in collaboration with the Spanish Foundation for Science and Technology - Ministry of Science and Innovation, several activities have been carried out in 2023: the Science and Gender Days, coordinated with CEFIRE, aimed at secondary school teachers; the performance of the play that brings to the stage the life of Lise Meitner, a pioneer of nuclear physics forgotten by the Nobel Prize committee; the 3rd Edition of the Express-Arte ConCiencia multidisciplinary competition, aimed at secondary school and professional training students, and the "Pioneers" exhibition, which has brought together the winning and selected works from the three editions of said competition held so far, and includes also a collection of works by the Italian artist Mónica Mura.

This year, the IFIC also hosted the presentation of the Complementary Plan for Astrophysics and High Energy Physics in the Valencian Community, coordinated by IFIC researcher Carlos Lacasta, with the participation of the regional minister for Innovation, Universities, Science and Digital Society, Josefina Bueno, among other

authorities. We also received a visit from the president of CSIC, Eloísa del Pino, and the rector of the University of Valencia, María Vicenta Mestre, as well as the regional secretary for Universities, M<sup>a</sup> Esther Gómez, and the director general for Science and Research, Rafael Sebastián.

In 2023, the IFIC management was renewed, so I would like to thank the entire management team, the outgoing vice-director, Berta Rubio, the incoming vice-director, Sergio Pastor, and the two vice-directors who continue, Michel Sorel and Jose Enrique Garcia Navarro, for their time, commitment and support.

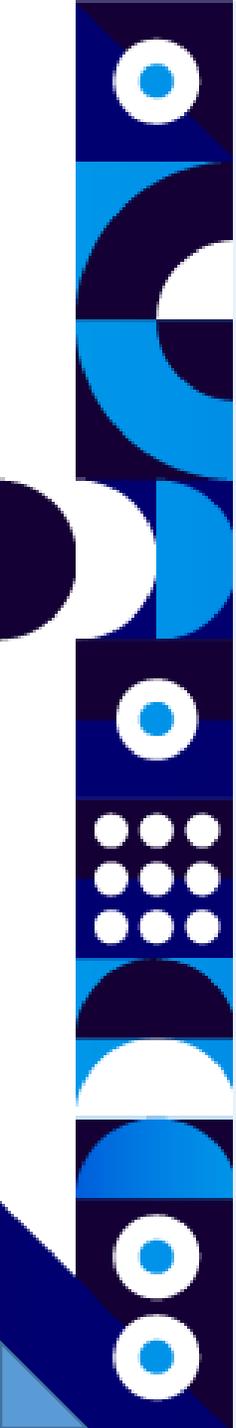
Finally, I would like to acknowledge the work and dedication of the members of IFIC, both the teaching and research staff and the technical, administrative and communication staff. Thanks to them, the numerous activities described in this report have been possible, and they are all necessary for us to maintain our international leadership.



**N**uria Rius

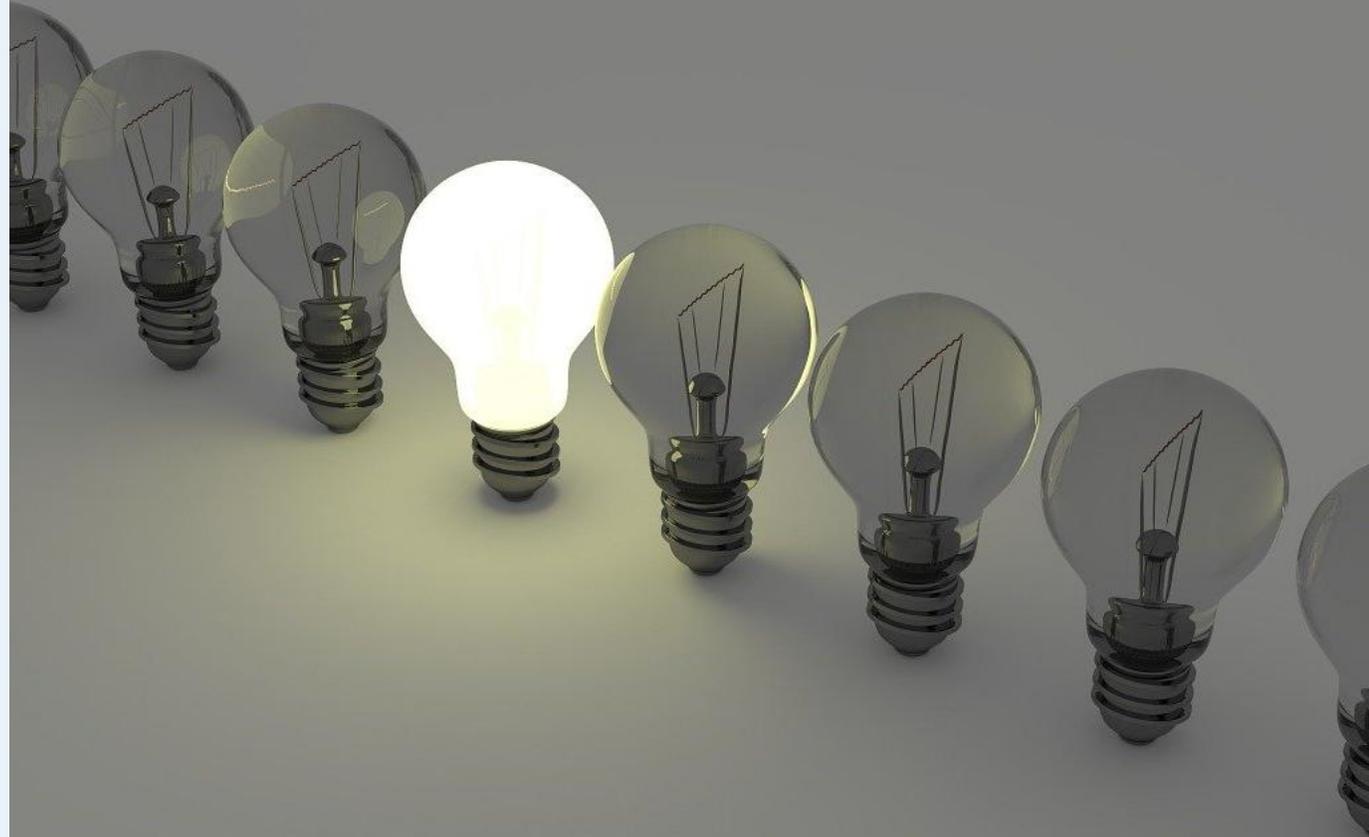
IFIC Director

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20

HIGHLIGHTS  
OF THE YEAR



## 2 HIGHLIGHTS OF THE YEAR

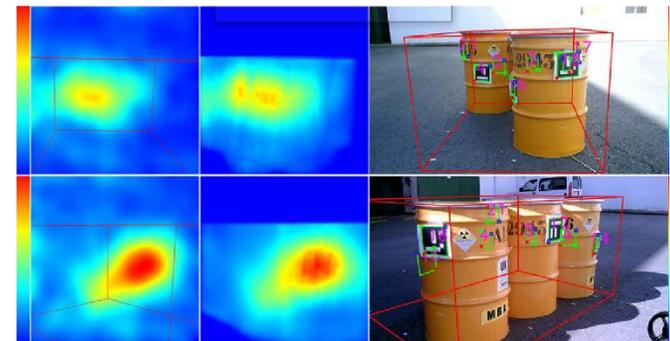
### THE PRESIDENT OF CSIC VISITS IFIC AND THE REST OF THE CENTERS THAT THE INSTITUTION HAS IN VALENCIA



IFIC received a visit from the president of CSIC, Eloísa del Pino, on the occasion of the trip that the president has made to Valencia to see, first-hand, the Valencian research centers housed by CSIC. During the visit to IFIC facilities, María Vicenta Mestre, rector of the University of Valencia, was also present. More information [here](#).

### IFIC AND ENRESA PRESENT AN INNOVATIVE TECHNOLOGY TO VISUALIZE THE ACTIVITY OF RADIOACTIVE WASTE IN CONTAINERS

IFIC, in collaboration with the public company responsible for radioactive waste management, Enresa, has developed a system to visualize the activity of radioactive waste in containers using a gamma ray tomography technique that is portable and independent of geometry. More information [here](#).



## 2 HIGHLIGHTS OF THE YEAR

### DIEGO REAL RECEIVES THE NIKOLA TESLA AWARD



The Official College of Industrial Technical Engineers of Valencia (COGITI Valencia) has presented the VII Nikola Tesla Awards. Diego Real, engineer at IFIC, has been the recipient of the award in the 'Prestigious Professional Career' category. More information [here](#).

### EULOGIO OSET RECEIVES THE MEDAL OF THE ROYAL SPANISH SOCIETY OF PHYSICS

The Royal Spanish Society of Physics (RSEF) and the BBVA Foundation have awarded the medal for merit in research and teaching of Physics 2023 to Eulogio Oset Báguena, member of IFIC and emeritus professor at the University of Valencia. Oset Báguena has been awarded for his “exceptional scientific career in the field of theoretical physics, which has made him a reference in nuclear physics.” More information [here](#).



## 2 HIGHLIGHTS OF THE YEAR

### **BERTA RUBIO, PRESIDENT OF NUSTAR, ONE OF THE PILLARS OF FAIR, THE FUTURE FACILITY FOR RESEARCH IN NUCLEAR PHYSICS**



IFIC researcher Berta Rubio Barroso has been elected as president of the NUSTAR Council. NUSTAR is an institution that represents the international community of Structure, Astrophysics and Nuclear Reactions. It is a scientific collaboration with 700 members and 170 institutions that forms one of the pillars of FAIR, the future nuclear physics research facility being built in Darmstadt, Germany. More information [here](#).

### **MARIA JOSÉ COSTA, HEAD OF THE NEW CPAN DIRECTORATE**

María José Costa, CSIC researcher at IFIC, assumes the direction of CPAN and Carlos Salgado, director of IGFAE and professor at USC, holds the position of deputy director. The CPAN is a project that emerged in 2007, within the framework of the Consolidar-Ingenio 2010 program, with the aim of actively promoting cooperation between Spanish research groups experts in particle, astroparticle and nuclear physics. More information [here](#).



## 2 HIGHLIGHTS OF THE YEAR

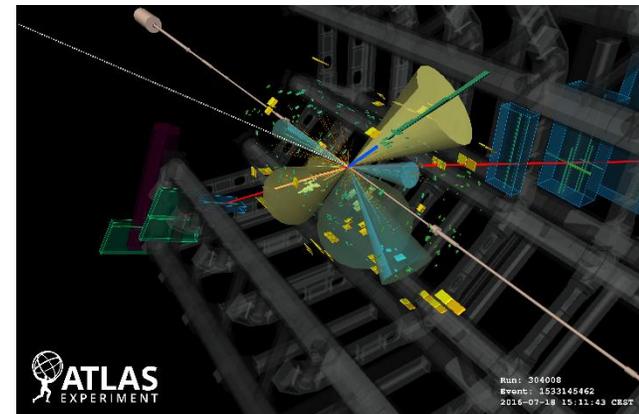
### IFIC PRESENTS THE COMPLEMENTARY R&D&I PLAN OF THE ASTROPHYSICS AND HIGH ENERGY PHYSICS PROGRAM IN THE VALENCIAN COMMUNITY



IFIC coordinates this R&D&I program that mobilizes close to 8 million euros in the Valencian Community, financing 30 research projects. The exploration of the largest and smallest of the universe is the objective, as well as the application of the technologies developed in the fight against cancer, among other fields. More information [here](#).

### LHC EXPERIMENTS OBSERVE A RARE PROCESS WITH FOUR TOP QUARKS, THE MOST MASSIVE PARTICLE KNOWN

The ATLAS experiment observes the simultaneous production of four top quarks in collisions at the world's largest particle accelerator at CERN. The IFIC plays a prominent role in the discovery, considered key to searching for new particles beyond the Standard Model. More information [here](#).



## 2 HIGHLIGHTS OF THE YEAR

### **JUAN JOSÉ HERNÁNDEZ-REY, CONFIRMED AS MEMBER OF THE CERN LHCC AND OF THE CNRS SCIENTIFIC COUNCIL**



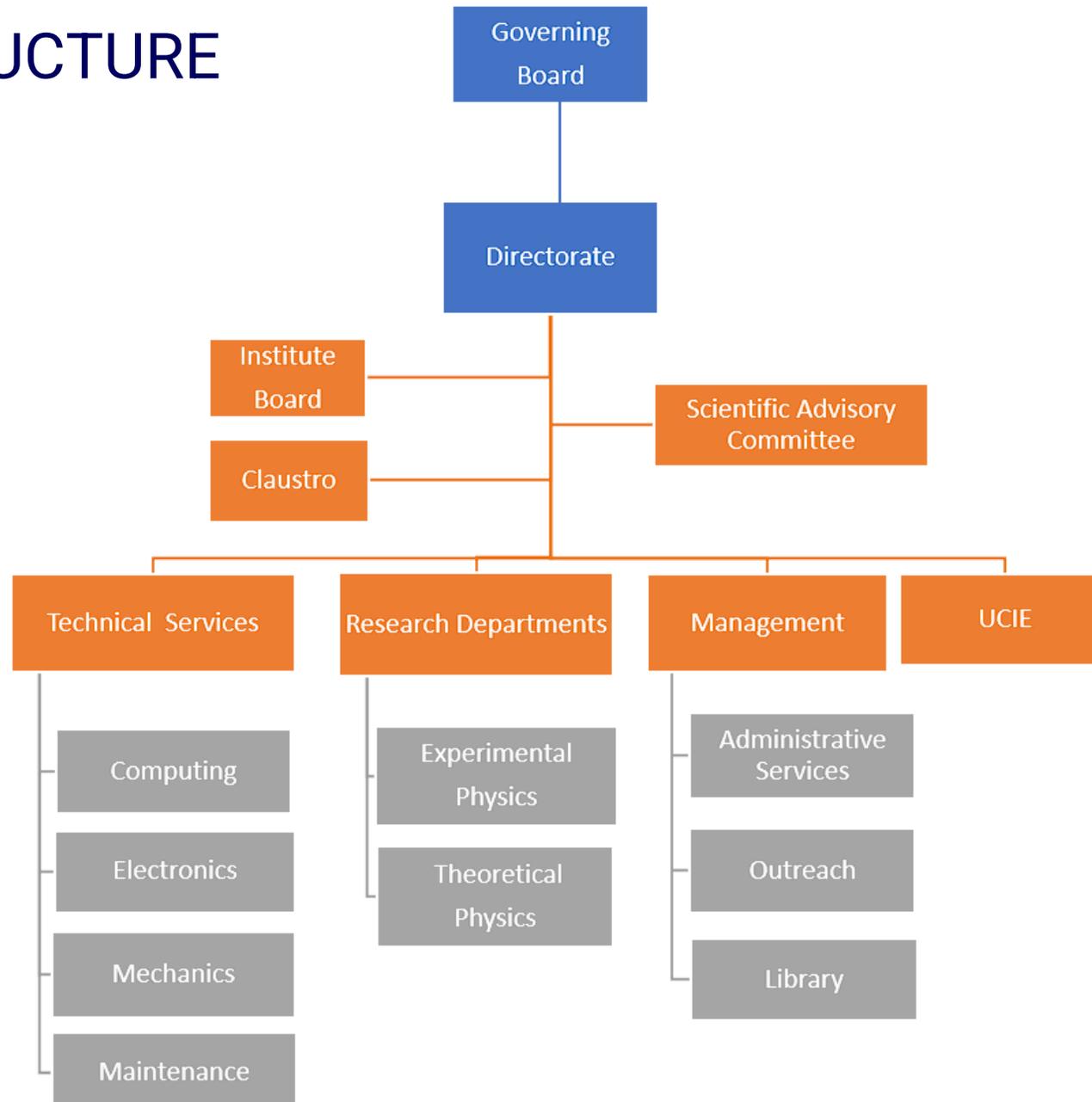
Juan José Hernández-Rey has been confirmed as member of the LHCC committee, which reviews the status and progress of the Large Hadron Collider (LHC) experiments at CERN, until 2025. He has also been confirmed as member of the Scientific Council of the National Center for Scientific Research (CNRS), the main research organization in France, until 2028.

# 3

## STRUCTURE AND ORGANIZATION



# 3 IFIC STRUCTURE



# 3 STRUCTURE

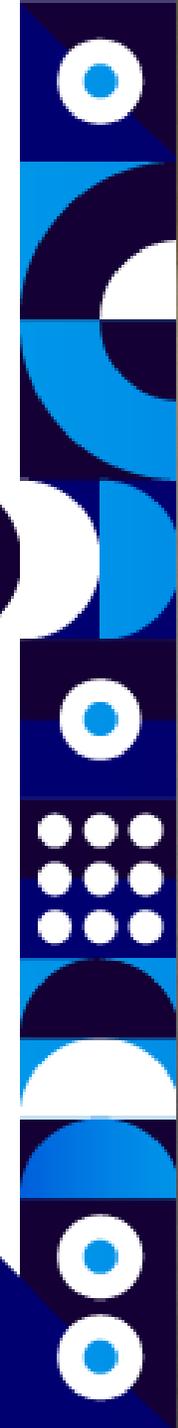
**Deputy Director**  
Sergio Pastor

**Manager**  
Ana Fandos

**Deputy Director**  
Michel Sorel

**Deputy Director**  
José E. García

**Director**  
Nuria Rius



# 3 STRUCTURE

Heads of the research departments

Experimental Physics  
Luca Fiorini

Theoretical Physics  
Luis Álvarez

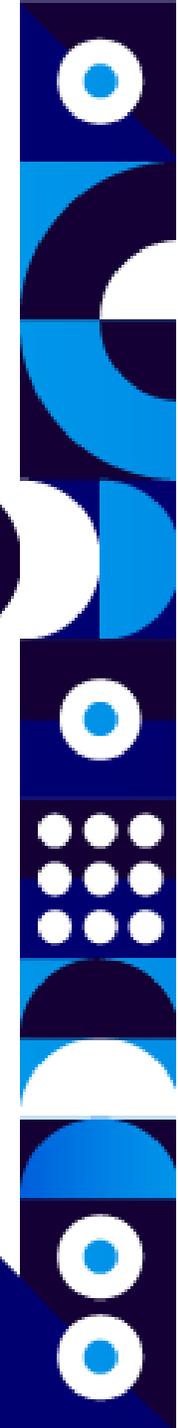
International Scientific  
Advisory Committee

Personnel representatives

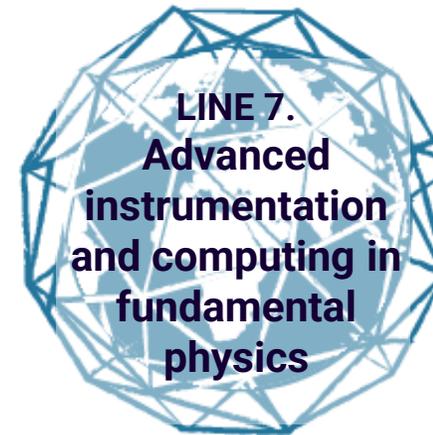
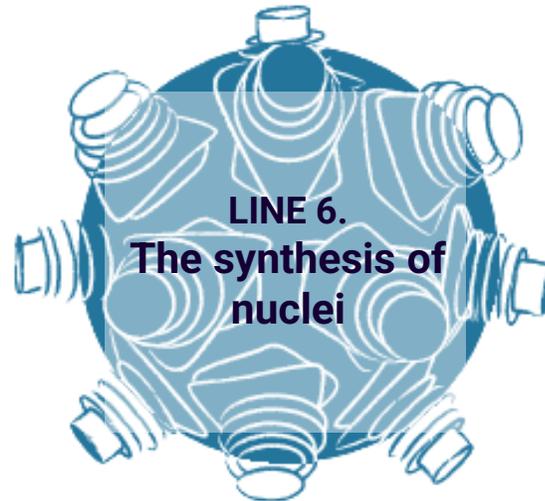
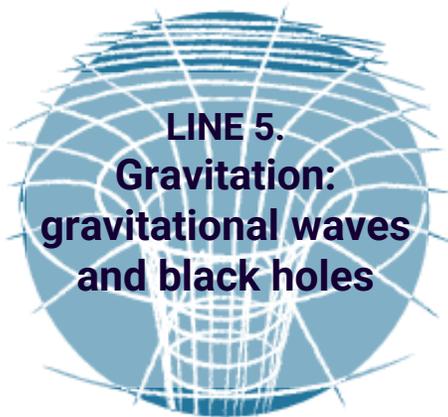
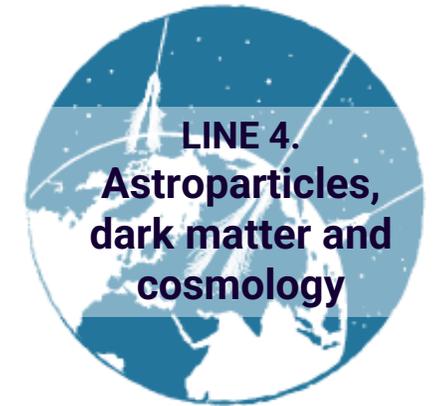
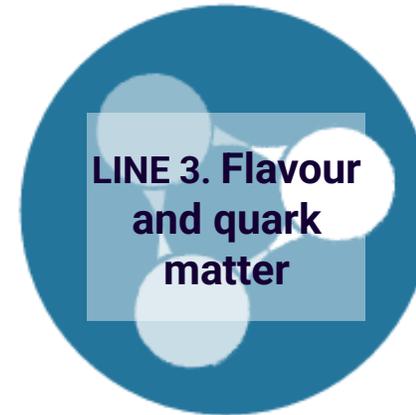
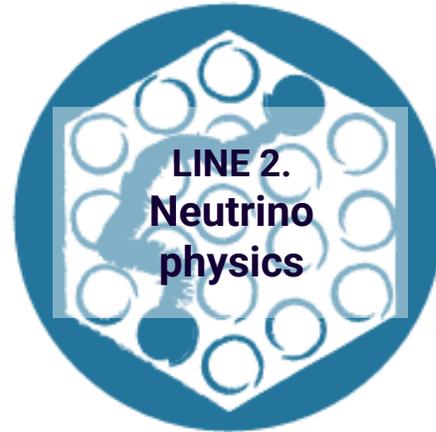
Non-PhD members  
Teresa Cámara

PhD members  
Martín González

- > Gustavo C Branco (CFTP/IST, Univ. Lisbon, Portugal)
- > William Gelletly (Univ. Surrey, UK)
- > Francis Halzen (Univ. Wisconsin, USA)
- > Manuella Vincter (Univ. Carleton, Canada, and CERN)
- > Antonio Masiero (INFN and Univ. Padua, Italy)
- > Tatsuya Nakada (EPFL Lausanne, Switzerland)
- > Bing-Song Zou (ITP, Chinese Academy of Sciences, China)

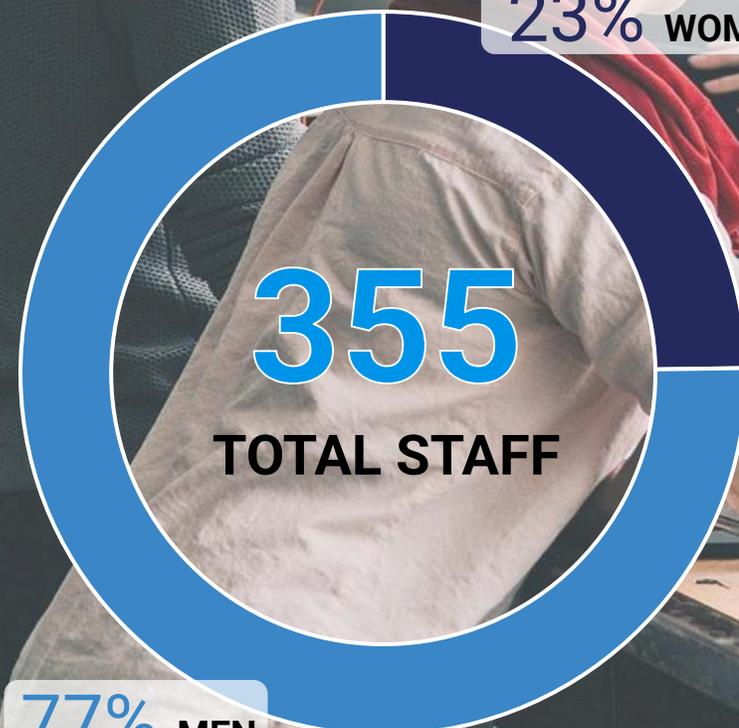


# RESEARCH LINES



# 3 PERSONNEL

DECEMBER 2023



23% WOMEN

77% MEN

[Personnel list](#)

6.2% Administrative staff

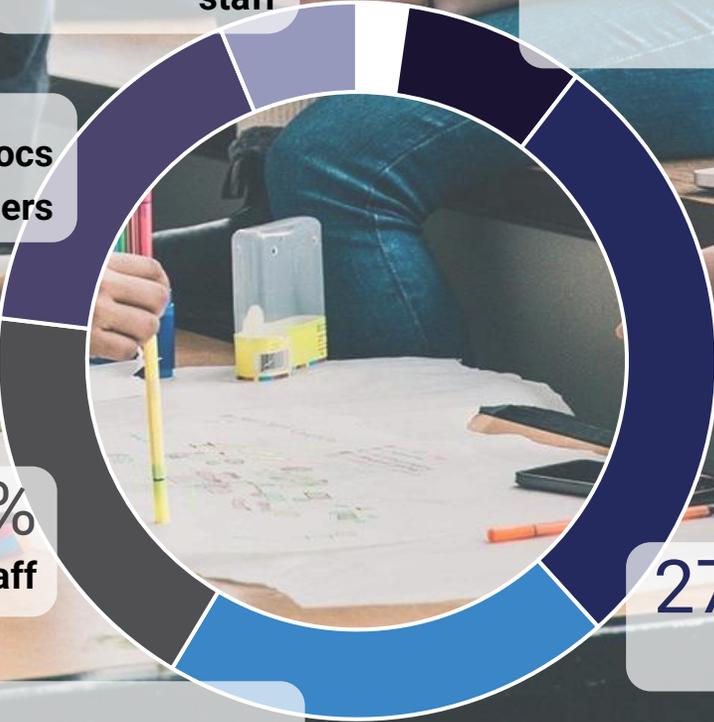
2.3% Professors emeriti and visiting researchers

8.2% Tenure track researchers

16.9% Post-docs researchers

18.2% Technical staff

20.3% Permanent staff researchers



27.9% PhD Students

4 

# SCIENTIFIC PRODUCTION



# 4 SCIENTIFIC OUTCOME

ARTICLES IN INDEXED JOURNALS **512\***

(ONLY DOCUMENT TYPE ARTICLE OR REVIEW). SEE ANNEX FOR FULL LIST OF PUBLICATIONS

**89.3%** IN FIRST QUARTILE JOURNALS

(JCR-WoS OR CITESCORE-SCOPUS, 2023)

## TOP 5 JOURNALS

(BY IMPACT FACTOR, JCR-WoS) WITH IFIC AUTHORS

Living Reviews in Relativity (IF 26.3) **1**  
Phys. rep.-review section of Phys. Letters (IF 23.9) **1**  
Science Bulletin (IF 18.8) **1**  
Nature Physics (IF 17.6) **1**  
Nature Communications (IF 14.7) **1**

## TOP 5 JOURNALS

(BY NUMBER OF PAPERS) WITH IFIC AUTHORS

**126** Journal of High Energy Physics (IF 5.0)  
**90** Physical Review D (IF 4.6)  
**63** European Physical Journal C (IF 4.4)  
**36** Physics Letters B (IF 4.3)  
**32** Physical Review Letters (IF 8.1)

An agreement on how to acknowledge authorship of Russian and Belarusian scientists on publications from the four largest LHC experiments (including ATLAS and LHCb) has been reached in February 2023. As a result, many 2022 articles have appeared as formal publications only in 2023, resulting in a higher than usual number of yearly publications for 2023.

[Full list of publications](#)

# 4 CONFERENCES, WORKSHOPS, SEMINARS AND COLLOQUIA

CONTRIBUTIONS  
TO CONFERENCES  
AND WORKSHOPS

CONFERENCES AND  
WORKSHOPS  
ORGANIZED

COLLOQUIA  
ORGANIZED

SEMINARS  
ORGANIZED

410

22

10

119

[Full list of events](#)

# 4.1 CONFERENCES AND WORKSHOPS

## CONTRIBUTIONS TO CONFERENCES AND WORKSHOPS

### NATIONAL AND INTERNATIONAL CONFERENCES

IFIC researchers present their results in the main international conferences and workshops. A total of 410 contributions were presented in 2023: 375 talks (22 invited, 70 plenaries) and 35 posters.

410

[Full list of events](#)

## CONFERENCES AND WORKSHOPS ORGANIZED

IFIC members have organized 22 conferences and workshops during 2023. The full listing can be found in Annex 3.

22

# 4<sub>2</sub> COLLOQUIA

## 'SEVERO OCHOA' COLLOQUIA ORGANIZED

The colloquium series "Severo Ochoa" invites world leading experts in their area of science. Lectures are primarily devoted to particle, astroparticle and nuclear physics, but also explore other areas. Colloquia are open to scientists, personnel and students of other research institutes and science faculties.

The outreach department shares Zoom recordings of the colloquia on the institute's Indico server. In 2023, IFIC celebrated 10 Severo Ochoa Colloquia. The listing can be found in Annex 4.

Organisers: Alejandro Algora, Sergio Palomares Ruiz and Marcel Vos.

[Full list of events](#)

10

## 4.3 SEMINARS

### SEMINARS ORGANIZED

Seminars are more specific research talks given by an invited speaker, usually connected to one of the IFIC research groups. Some of them are more informal talks followed by a discussion session, such as those within the Student Seminars series. In 2023 we hosted a total of 119 seminars, including 28 student seminars. The complete list can be found in Annex 5.

Organisers: Josu Cantero, Leandro Cieri, Andrea Donini, Carlos Escobar, Daniel G. Figueroa, Adrián Irles, Nicolás Loayza, Jacobo López, Neus López, Pablo Martinez, Omar Medina, Laura Molina, Raquel Molina, David Muñoz, Miguel Nebot, Sergio Palomares, Alberto Prades, David Valles, Avelino Vicente.

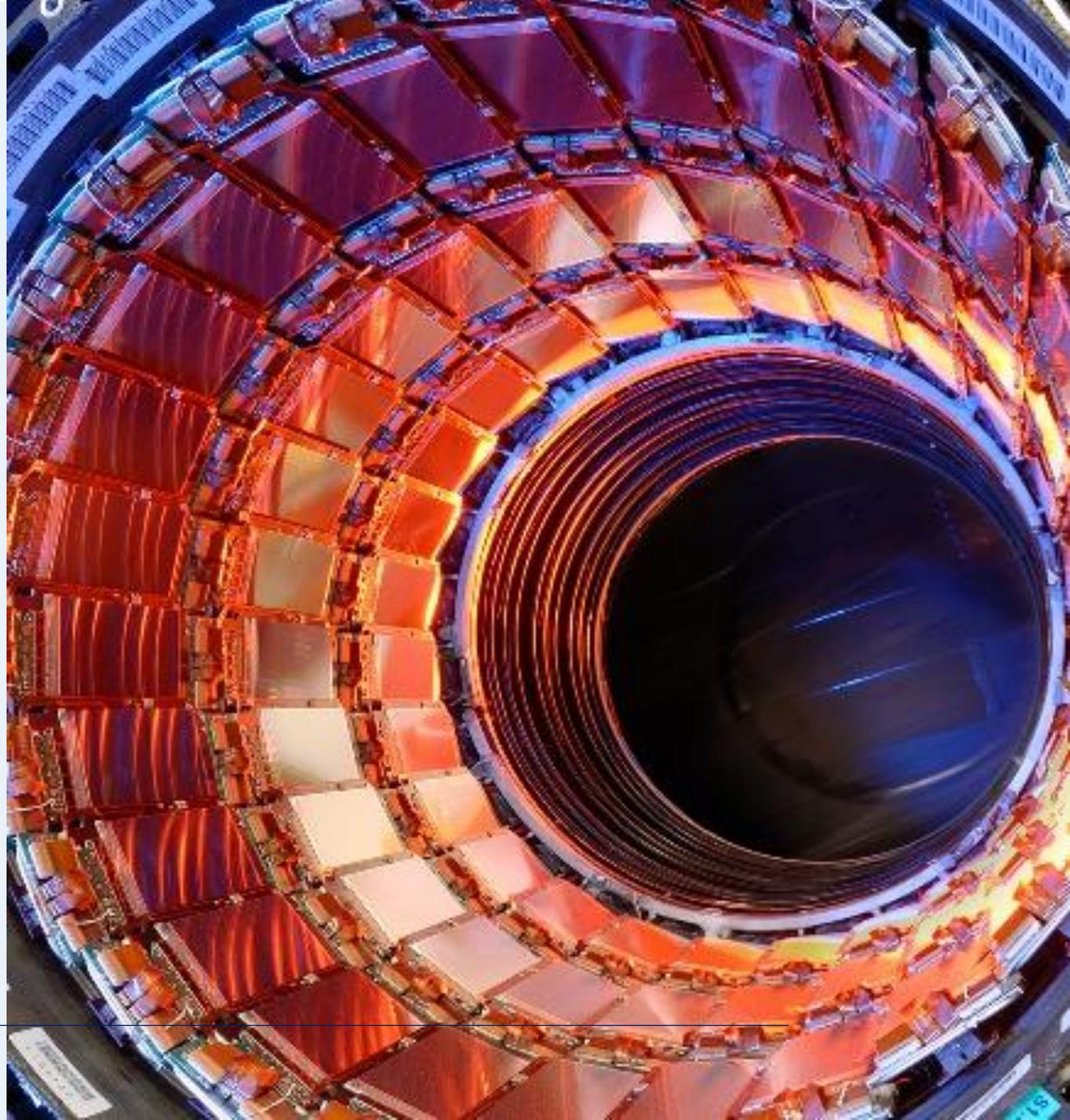
[Full list of events](#)

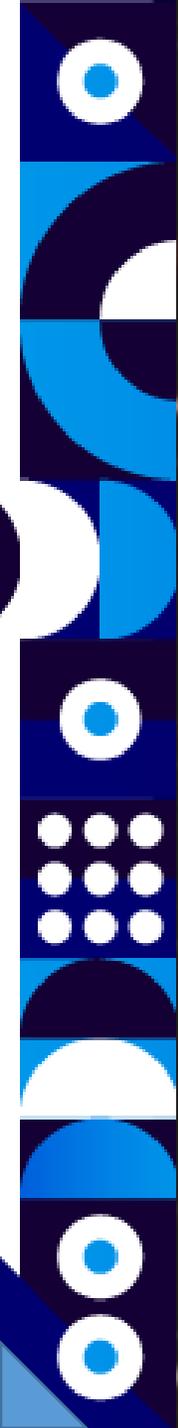
119

# 5

## RESEARCH

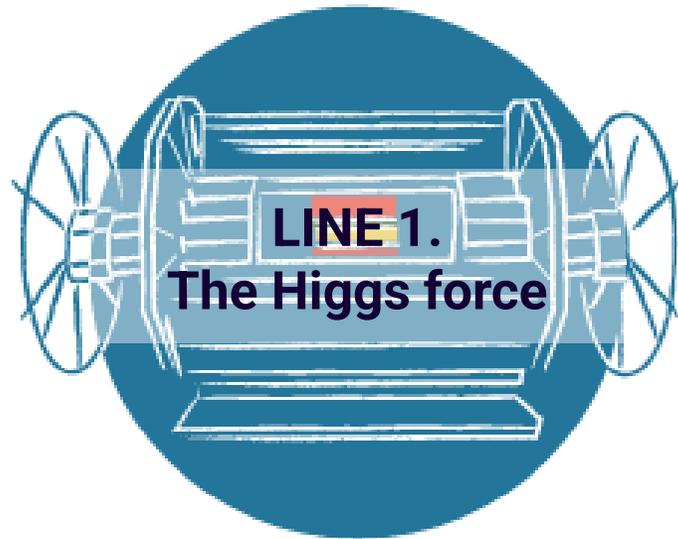
## REPORT





# THE ORIGIN OF MASS

# SCIENTIFIC RESEARCH LINES



The goal is to reach a deeper understanding of the Higgs force from LHC Run 3 at CERN with the ATLAS experiment and future colliders. The focus is on the interactions of the Higgs boson and the top quark, novel methodologies and formal developments for beyond state-of-the-art theoretical predictions and phenomenological analysis at higher orders in perturbative quantum field theory, as well as in the theoretical interpretation of the experimental data in terms of effective field theories (SMEFT, HEFT), which contain a large number of parameters and call for innovative methods in parameter fitting, e.g. using Machine Learning techniques. At the same time, this line aims to continue the direct search for new particles at the energy frontier.

# 5

## L1: THE HIGGS FORCE

During 2023, the Large Hadron Collider (LHC) at CERN continued operations during the Run 3 of the LHC. Collisions continued at the world record energy in the center of mass of 13.6 TeV until a quench of an LHC inner triplet magnet in July caused a small leak, but with major consequences, because it terminated p-p collisions abruptly ahead of time. The LHC restarted operation in autumn, colliding lead ions until the 30th of October. In total, an integrated luminosity of 31.9 fb<sup>-1</sup> of p-p collisions and 1.9 nb<sup>-1</sup> of lead-ion collisions have been delivered by LHC to each major experiment.

### ATLAS Operations

During 2023, IFIC members contributed to the ATLAS detector operations, the trigger system and the reconstruction of the physics objects. ATLAS pushed the limits of the detectors to make the most of the high intensity beams delivered by LHC.

The ATLAS Level 1 trigger rate reached 100 kHz just two months after the start of the data-taking, with a 5% deadtime. ATLAS improved the readout to reduce the L1 trigger rate to manage operations with a number of interactions per bunch crossing of 60 collisions. The Level 1 trigger rate was reduced thanks to the new digital trigger readout of the Lar calorimeter. Similarly, the Level 1 trigger readout of the muon system

was reduced thanks to the use of the New Small Wheel and the Tile Calorimeter detectors. IFIC has been involved in the operation of the ATLAS trigger system throughout the data taking in 2023, as well as the trigger software validation, trigger menu configuration and tau lepton trigger identification performance studies.

IFIC participates in the operations of the Inner Detector tracker of the ATLAS detector. The semiconductor tracker (SCT) operated smoothly with high hit efficiency. The Pixel b-layer, the innermost layer of the tracker, showed stable operations up to 65 interactions per bunch crossing. The Inner Detector alignment was further automatized and its graphics improved for better diagnostics.

The IFIC team was in charge of the operations and calibrations of the ATLAS Tile Calorimeter during 2023. The Tile Calorimeter worked smoothly during 2023. The demonstrator, a prototype which operates with Phase-II electronics, continued to work correctly during the 2023 data-taking, proving the reliability of the future Phase-II electronics.

Our group plays a leading role in the electron, muon, photon, jet and tau-lepton performance studies in ATLAS.

### Precision measurements Higgs/Top

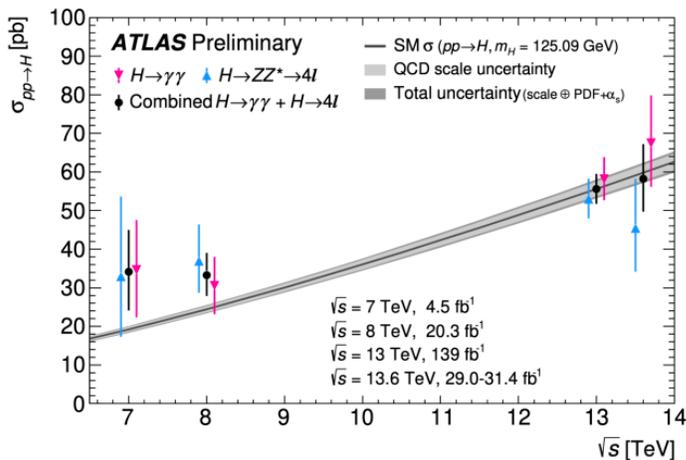
The ATLAS group at IFIC continues to be heavily involved in the exploitation of the data

collected by the experiment. Our researchers contributed to the first Higgs cross-section measurement of the Higgs boson at an energy in the center of mass of 13.6 TeV with Run 3 data of the LHC in the  $H \rightarrow ZZ^* \rightarrow 4\ell$  channel (Eur. Phys. J. C 84 (2024) 78). This measurement has been carried out in the final state with four light leptons (electrons or muons) and it has been combined with a similar measurement in the  $H \rightarrow \gamma\gamma$  channel to improve the precision of the Higgs boson cross-section measurement.

One of the areas where IFIC has a major impact is top quark physics. Among several important results, the measurement of the charge asymmetry in top quark pair production (JHEP08 (2023) 077), with an important contribution from IFIC, has obtained evidence for this effect to be consistent with the Standard Model (SM) and provided. We also participated in the inclusive and differential production cross-section measurements of a top-quark-top-antiquark pair in association with a Z boson (arXiv:2312.04450). Additionally, IFIC led a pioneering measurement of the asymmetry in ttW production (JHEP07 (2023) 033) jointly with other on-going activities in the context of the measurements of the top quark mass and new quantum information studies. During 2023, IFIC continued to coordinate the top physics working group, giving important visibility to the group.

# 5 L1: THE HIGGS FORCE

IFIC contributed to the measurement for the production cross-section of a Z boson in association with high-energy jets using Run 2 data acquired by the ATLAS detector (JHEP 06 (2023) 080). This measurement is performed in extreme phase spaces with the collinear emission of a Z boson in dijet events to probe the interplay between QCD and higher-order electroweak corrections. Results are compared to the state-of-the-art theoretical predictions for this kinematic regime where large NLO corrections are expected.



Values of the  $\sigma$  measurements from this and previous ATLAS publications as a function of the centre-of-mass energy. The Standard-Model predicted values and their uncertainties are shown by the grey band.

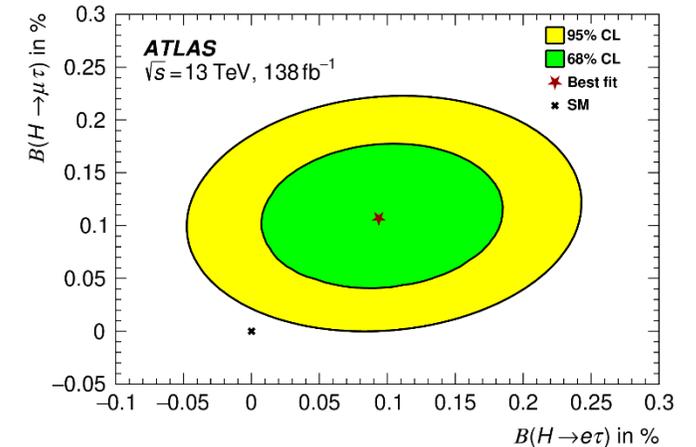
## Searches Higgs/Top

IFIC researchers are involved in the study of the Higgs and Top sectors and greatly contributed to the search for new phenomena beyond the Standard Model (BSM).

Many BSM theories predict new massive vector bosons, typically called  $Z'$  and  $W'$  bosons, that can couple with the SM quarks and leptons. For some of them, couplings between  $Z'$  and  $W'$  bosons and the third family of SM quarks are preferred. IFIC researchers have collaborated in the ATLAS search of the production of  $W'$  boson decaying into a top and a bottom quark (JHEP 12 (2023) 073). In addition, IFIC researchers have also collaborated in the search for  $Z'$  boson production looking at final states where three or four top quarks are produced (Eur. Phys. J. C 84 (2024) 157). For these processes, only couplings between the  $Z'$  and top quarks are considered which is suitable to test BSM models including the so-called "top-philic" heavy resonances.

Lepton number is conserved in the SM theory, but lepton flavour violation (LFV) is known to exist in nature, as this phenomenon has been observed in neutrino oscillations. This observation motivates searches for additional manifestations of LFV that may originate from beyond-the-Standard Model physics. IFIC members of the ATLAS collaboration participated to the searches for Higgs boson decays  $H \rightarrow e\tau$  and  $H \rightarrow \mu\tau$  (JHEP 07 (2023) 166), based on the full Run 2 data set,

collected at a centre-of-mass energy of 13 TeV. The observed (expected) upper limits on the branching fractions  $B(H \rightarrow e\tau)$  and  $B(H \rightarrow \mu\tau)$  at 95% confidence level are 0.20% and 0.18%, respectively, which are the most stringent limits obtained by the ATLAS experiment on these quantities. The result of the simultaneous measurement of the  $H \rightarrow e\tau$  and  $H \rightarrow \mu\tau$  branching fractions is compatible with the SM prediction within 2.2 standard deviations.



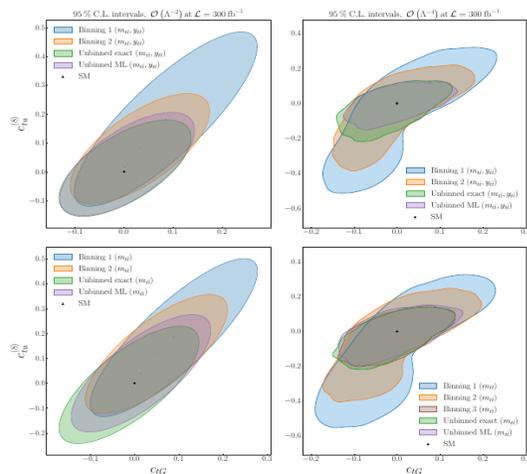
Best-fit value (red star) of the branching ratios  $B(H \rightarrow e\tau)$  and  $B(H \rightarrow \mu\tau)$ , given in %, and likelihood contours at 68% and 95% CL obtained from the simultaneous fit of  $H \rightarrow e\tau$  and  $H \rightarrow \mu\tau$  signals based on the MC-template method, compared with the SM expectation (black cross).

# 5 L1: THE HIGGS FORCE

## Theory

On the other hand, in 2023 IFIC researchers have co-authored an important work on the integration of unbinned multivariate observables into global Standard Model Effective Field Theory (SMEFT). Theoretical interpretations of particle physics data, such as the determination of the Wilson coefficients of the Standard Model Effective Field Theory (SMEFT), often involve the inference of multiple parameters from a global dataset. Optimizing such interpretations requires the identification of observables that exhibit the highest possible sensitivity to the underlying theory parameters. In this work we develop a flexible open source framework, ML4EFT, enabling the integration of unbinned multivariate observables into global SMEFT fits. As compared to traditional measurements, such observables enhance the sensitivity to the theory parameters by preventing the information loss incurred when binning in a subset of final-state kinematic variables. Our strategy combines machine learning regression and classification techniques to parameterize high-dimensional likelihood ratios, using the Monte Carlo replica method to estimate and propagate methodological uncertainties. As a proof of concept we construct unbinned multivariate observables for top-quark pair and Higgs+Z

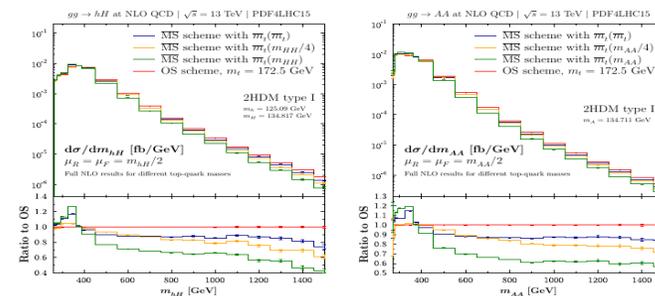
production at the LHC, demonstrate their impact on the SMEFT parameter space as compared to binned measurements, and study the improved constraints associated to multivariate inputs. Since the number of neural networks to be trained scales quadratically with the number of parameters and can be fully parallelized, the ML4EFT framework is well-suited to construct unbinned multivariate observables which depend on up to tens of EFT coefficients, as required in global fits.



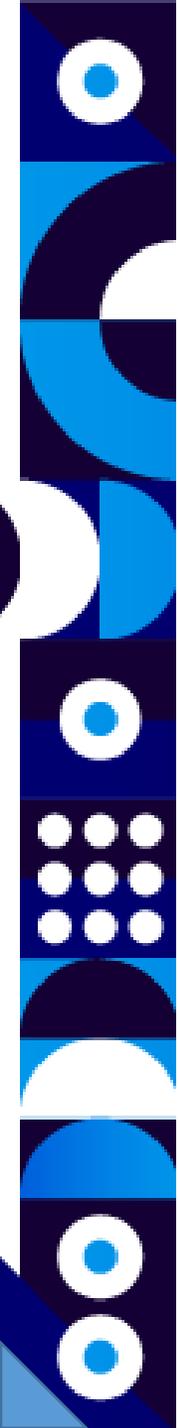
The 95% CL regions in the  $(ctG, ctu)$  plane obtained for the parton-level top quark pair production process described in Sect. 4.2 of the paper. We present results based on EFT calculations at the linear level (left) and also including quadratic contributions (right panels).

In 2023, IFIC theorists have also contributed to compute the full next-to-leading order (NLO) QCD corrections to Higgs pair production in the 2-Higgs-doublet model.

After the discovery of the Higgs boson in 2012 at the CERN LHC, the study of its properties still leaves room for an extended Higgs sector with more than one Higgs boson. 2-Higgs doublet models (2HDMs) are well-motivated extensions of the SM with five physical Higgs bosons: two CP-even states  $h$  and  $H$ , one CP-odd state  $A$ , and two charged states  $H^\pm$ . In this letter, we present the calculation of the full next-to-leading order (NLO) QCD corrections to  $hH$  and  $AA$  production at the LHC in the 2HDM at small values of the ratio of the vacuum expectation values,  $\tan\beta$ , including the exact top-mass dependence everywhere in the calculation. Using techniques applied in the NLO QCD SM Higgs pair production calculation, we present results for the total cross section as well as for the Higgs-pair-mass distribution at the LHC. We also provide the top-quark scale and scheme uncertainties which are found to be sizeable.



TeV LHC with different scale and scheme for the top-quark mass, in the 2HDM type I. Left: CP-even  $hH$  production. Right: CP-odd  $AA$  production. The lower panels display the ratio to the default OS prediction.



# 5

## L1: THE HIGGS FORCE

### Selected Publications

ATLAS Collaboration. *Searches for lepton-flavour-violating decays of the Higgs boson into  $e\tau$  and  $\mu\tau$  in  $s\sqrt{=13}$  TeV  $pp$  collisions with the ATLAS detector.* Journal of High Energy Physics 07 (2023) 166 [DOI](#) [\[arXiv\]](#)

ATLAS Collaboration. *Measurement of the  $H\rightarrow\gamma\gamma$  and  $H\rightarrow ZZ^*\rightarrow 4\ell$  cross-sections in  $pp$  collisions at  $s\sqrt{=13.6}$  TeV with the ATLAS detector.* European Physical Journal C 84 (2024) 78 [DOI](#) [\[arXiv\]](#)

ATLAS Collaboration. *Search for leptonic charge asymmetry in  $t\bar{t}W$  production in final states with three leptons at  $s\sqrt{=13}$  TeV.* Journal of High Energy Physics 07 (2023) 033 [DOI](#) [\[arXiv\]](#)

Raquel Gomez Ambrosio, Jaco ter Hoeve, Maeve Madigan, Juan Rojo, Veronica Sanz. *Unbinned multivariate observables for global SMEFT analyses from machine learning.* JHEP 03 (2023) 033. [DOI](#).

J. Baglio, F. Campanario et al. *Full NLO QCD predictions for Higgs-pair production in the 2-Higgs-doublet model.* Eur.Phys.J.C 83 (2023) 9, 826. [DOI](#).

### Selected Conference Talks

Susana Cabrera. *Highlights on top quark physics with the ATLAS experiment at the LHC,* [SUSY 2023](#). Southampton (UK).

Luca Fiorini. *Higgs boson couplings at ATLAS,* [LHCP2023](#). Belgrade (Serbia).

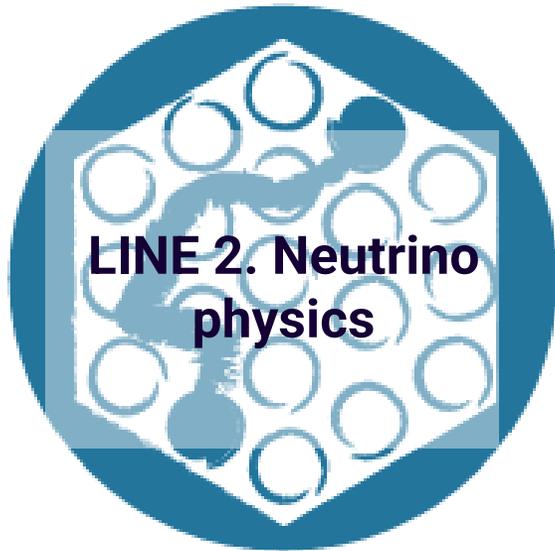
Marcel Vos. *Rare electroweak production measurements,* [31st International Symposium on Lepton Photon Interactions at High Energies](#). Melbourne (Australia).

Arantxa Ruiz. *Probing the nature of electroweak symmetry breaking with Higgs boson pairs in ATLAS,* [Lake Louise Winter Institute 2023](#). Lake Louise (Canada).

Ximo Poveda. *Property measurements of the Higgs boson production in association with top quark at the ATLAS detector,* [Higgs 2023](#). Beijing (China).

María Moreno. *SMEFT fits for the top quark couplings at the LHC and future colliders,* [EPS 2023](#). Hamburg (Germany).

# SCIENTIFIC RESEARCH LINES



The aim is to reconstruct the origin of neutrino mass from neutrino properties. The strategic objectives include: A) analyzing upcoming data from current neutrino experiments with IFIC participation (NEXT-100, KM3NeT-ORCA); B) constructing a new detector to measure beta decay spectra shapes to improve the determination of the primary fluxes of reactor neutrinos; C) playing a leading role in the three science pillars of the next-generation neutrino experiment DUNE: long-baseline oscillation physics, detection of astrophysical neutrinos, and new physics searches; D) continuing state-of-the-art global analyses of neutrino and cosmological measurements to pin down neutrino properties and E) continuing to reduce the uncertainties in neutrino-nucleus cross-sections, that are the dominant systematic error in present and future neutrino oscillation experiments.

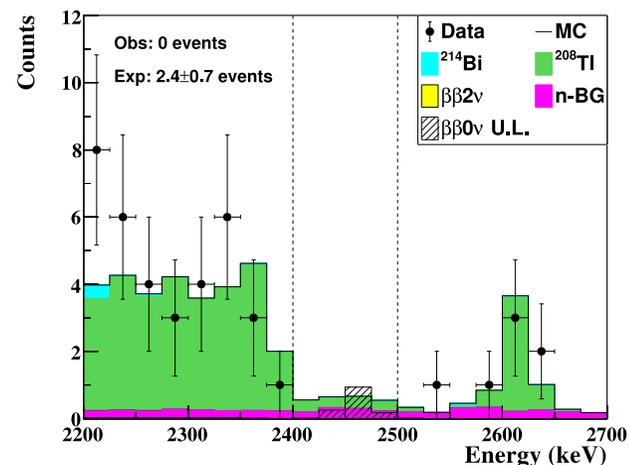
## 5 L2: NEUTRINO PHYSICS

The confirmation that neutrinos are massive has led to spectacular experimental progress in particle physics. This discovery was awarded the Nobel Prize in Physics in 2015 and constitutes a clear deviation from the Standard Model. The research lines at IFIC, a leading institute in both experimental and theoretical neutrino physics, explore the properties of these elusive particles, such as their mass and mixing pattern or the neutrino nature.

IFIC is involved in two long-baseline accelerator neutrino experiments: Tokai to Kamioka (T2K) in Japan and the future Deep Underground Neutrino Experiment (DUNE) in the United States. T2K is a world-leading experiment studying the neutrino mixing pattern and their CP properties, while DUNE is the next generation project. IFIC contributed strongly to the T2K measurements of the neutrino flux and cross sections, as well as of the oscillation parameters. IFIC researchers have also led a joint analysis of neutrino oscillations using data from T2K and reactor neutrino experiments, particularly the Daya Bay reactor experiment ([PhD thesis](#) by Maria Antonova).

Our institute is also involved in the design and construction of the DUNE far detectors and

their prototypes at the CERN Neutrino Platform, having important responsibilities at the technical level, as discussed in more detail in L7. IFIC members are also leading some of the physics groups and are developing important analyses, such as the identification of secondary kaons in the CERN prototypes and its impact on future proton decay searches in the far detectors ([PhD thesis](#) by Miguel Angel Garcia Peris).



NEXT-White energy spectrum in the energy region of interest for  $^{136}\text{Xe}$   $\beta\beta_{0\nu}$  searches. The data are superimposed to the best-fit background expectations and to the  $\beta\beta_{0\nu}$  signal corresponding to the obtained upper limit rate at 90% confidence level [1].

The discovery of an extremely rare radioactive process, neutrinoless double beta decay ( $\beta\beta_{0\nu}$ ), would prove that neutrinos are

Majorana particles, making neutrinos very special particles, "double agents" of the matter and antimatter realm. IFIC is the proponent and a major leader of the Neutrino Experiment with a Xenon TPC (NEXT), that has developed a new technology to search for  $\beta\beta_{0\nu}$  using a high pressure  $^{136}\text{Xe}$  time projection chamber (TPC), and is the flagship experiment of the national Canfranc Underground Laboratory (LSC).

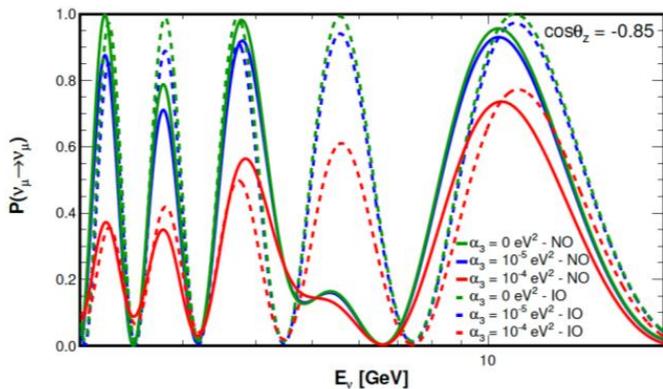
The first radiopure implementation of the NEXT technology holding 5 kg of Xe, the NEXT-White detector, successfully completed its physics program in 2021, while the NEXT-100 detector (up to 100 kg of Xe) was installed at the LSC during 2023.

The NEXT Collaboration published in 2023 its results on the search for  $\beta\beta_{0\nu}$  in  $^{136}\text{Xe}$  with NEXT-White [1], leveraging on the same data samples and analysis techniques employed for the measurement of the two-neutrino double beta decay in  $^{136}\text{Xe}$  ([PhD thesis](#) by Alberto Usón). This analysis, led by IFIC researchers, considers the combination of 271.6 days of  $^{136}\text{Xe}$ -enriched data and 208.9 days of  $^{136}\text{Xe}$ -depleted data, where the latter is used for constraining the backgrounds.

No  $\beta\beta_{0\nu}$  signal was found, and the corresponding limits on this decay mode were reported. The published techniques stand as a proof-of-concept for the searches to be implemented in larger gaseous xenon detectors, such as NEXT-100.

# 5

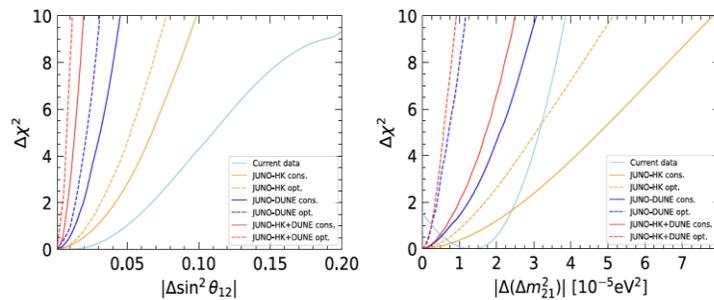
## L2: NEUTRINO PHYSICS



Muon neutrino survival probabilities as a function of energy at a cosine of the zenith angle,  $\cos \theta_z = -0.85$ . Three values of the putative neutrino decay constant  $\alpha_3 = m_3/\tau_3$  are considered, where  $\alpha_3 = 0$  is the case for stable neutrinos [2].

Neutrinos produced in cosmic-ray showers in the atmosphere have been essential to measure neutrino properties. Data from neutrino telescopes on the highest energy tail of these atmospheric fluxes can be used to this end. One of the main research lines of the ANTARES/KM3NeT (VEGA) group at IFIC is the study of neutrino properties, including the search for non-standard neutrino interactions ([PhD thesis](#) by Jerzy Manczak) or neutrino decays, the measurement of the oscillation parameters and the study of quantum decoherence. Other tasks carried out are the contributions to MC simulations for neutrino

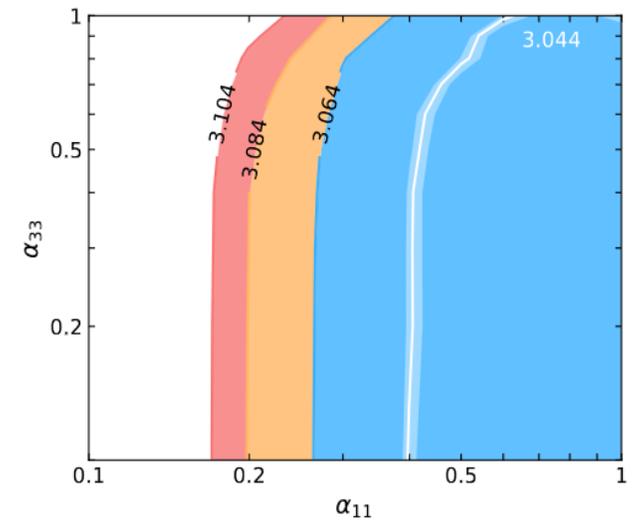
and atmospheric muon background and the development of the machine learning algorithm that is used to identify particles in KM3NeT/ORCA. In 2023, competitive results in several of these topics have been presented thanks to the data gathered by part of the about 40 lines installed by then. For instance, in the analysis presented at the ICRC 2023 conference, results on the parameter  $\alpha_3 = m_3/\tau_3$ , used to describe the invisible neutrino decay, showed a preference for  $\alpha_3 = 1.08 \cdot 10^{-4} \text{ eV}^2$  with respect to the stable scenario ( $\alpha_3=0$ ). Sensitivities for the full ORCA detector have also been recently published [2] and are expected to improve by two orders of magnitude after 10 years of data taking with the complete detector.



Future sensitivity to CPT-violating neutrino and antineutrino oscillation parameters for different configurations and combinations of experiments in comparison with the current bounds [3].

IFIC neutrino theorists are world leaders in exploring the new physics associated with the origin of neutrino mass or in the determination of neutrino properties from all current and upcoming oscillation experiments, as well as

complementary observations such as  $\beta\beta 0\nu$  decay results or cosmological data. For instance, as shown in [3], neutrinos offer the opportunity not only to test extended models of particle physics, but also to test the paradigm of local relativistic quantum field theory, which predicts CPT invariance. The authors place new bounds on CPT violation in the solar neutrino sector analyzing the results from solar experiments and KamLAND, including also a discussion of sensitivity of the next-generation experiments DUNE and Hyper-Kamiokande (HK), which will provide accurate measurements of the solar neutrino oscillation parameters.



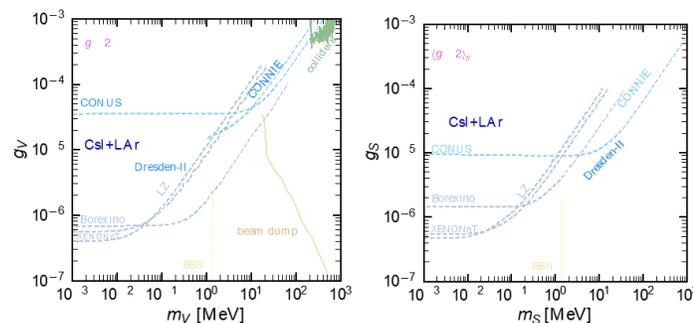
Contribution of neutrinos to the cosmological radiation, measured with the parameter  $N_{\text{eff}}$ , in the presence of non-unitarity in the three-neutrino mixing. We show the case of non-zero diagonal parameters  $\alpha_{ii}$  [4].

## 5

## L2: NEUTRINO PHYSICS

Neutrinos are the second most abundant of all known particles in the cosmos and they can influence its evolution, leaving measurable features in the cosmic microwave background and the distribution of galaxies. In 2023, the authors of [4] analyzed the impact of non-unitarity in the three-neutrino mixing matrix on the process of neutrino decoupling in the early Universe. Non-unitarity effects have an impact on the value of the effective number of neutrinos,  $N_{\text{eff}}$ , a parameter that will be measured very accurately from forthcoming cosmological observations ([PhD thesis](#) by Pablo Martínez-Miravé).

IFIC theorists have also considered the implications for particle physics and astrophysics of coherent elastic neutrino-nucleus scattering (CEvNS), a process measured by the COHERENT collaboration using two different targets, first CsI and then liquid argon. In [5], they perform a detailed statistical analysis of the full CsI data and combine it with the previous argon result. Our team discusses a vast array of implications, from tests of the Standard Model to new physics probes. In many cases, the inclusion of the recent CsI data leads to a dramatic improvement of bounds.

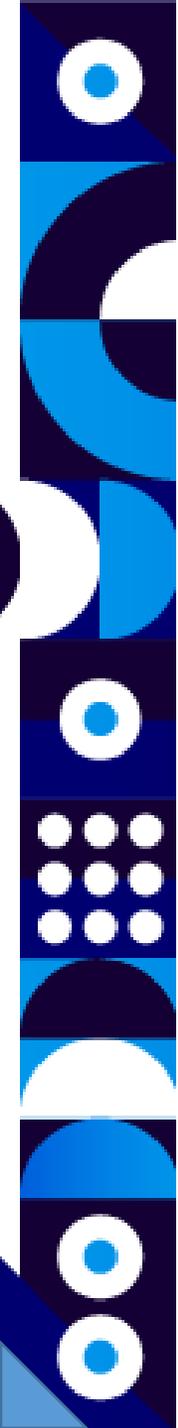


Exclusion regions from the combined analysis of CsI+LAr COHERENT data for vector (left) and scalar (right) light mediators coupled universally to neutrinos and quarks, compared with other experimental constraints [5].

Neutrinos can be also used as probes to determine the internal structure of Earth, a method called neutrino tomography which is completely different from traditional ones that mainly rely on the study of seismic waves, along with constraints from gravitational measurements. In 2023, IFIC theorists have revisited the possibility to perform Earth (oscillation) tomography with galactic supernova neutrinos at future detectors (DUNE, HK, and JUNO), operating at planned facilities [6].

## Selected Publications

- [1] NEXT Collaboration, *Demonstration of neutrinoless double beta decay searches in gaseous xenon with NEXT*, Journal of High Energy Physics **09** (2023) 190 [DOI](#) [\[arXiv\]](#)
- [2] KM3NeT Collaboration, *Probing invisible neutrino decay with KM3NeT/ORCA*, Journal of High Energy Physics **04** (2023) 090 [DOI](#) [\[arXiv\]](#)
- [3] G. Barenboim, P. Martínez-Miravé, C.A. Ternes, M. Tórtola, *Neutrino CPT violation in the solar sector*, Physical Review D **108** (2023) 035039 [DOI](#) [\[arXiv\]](#)
- [4] S. Gariazzo, P. Martínez-Miravé, O. Mena, S. Pastor, M. Tórtola, *Non-unitary three-neutrino mixing in the early Universe*, Journal of Cosmology and Astroparticle Physics **03** (2023) 046 [DOI](#) [\[arXiv\]](#)
- [5] V. De Romeri, O.G. Miranda, D.K. Papoulias, G. Sánchez García, M. Tórtola, J.W.F. Valle, *Physics implications of a combined analysis of COHERENT CsI and LAr data*, Journal of High Energy Physics **04** (2023) 035 [DOI](#) [\[arXiv\]](#)
- [6] R. Hajjar, O. Mena, S. Palomares-Ruiz, *Earth tomography with supernova neutrinos at future neutrino detectors*, Physical Review D **108** (2023) 083011 [DOI](#) [\[arXiv\]](#)



# 5

## L2: NEUTRINO PHYSICS

### Selected Conference Talks

A.A. García Soto, *New results for eV-scale sterile neutrino searches with IceCube*, [TeV Particle Astrophysics \(TeVPA 2023\)](#). Naples (Italy)

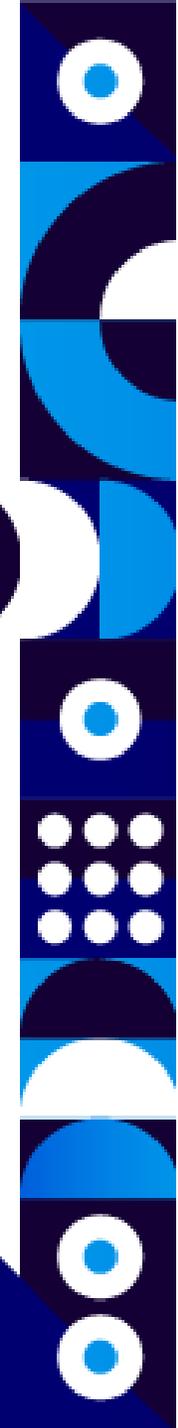
R. Gozzini, *Latest Results with the KM3NeT Neutrino Telescope*, [18th International Conference on Topics in Astroparticle and Underground Physics \(TAUP 2023\)](#). Vienna (Austria)

O. Mena, *Cosmological limits on neutrino masses and species*, [XX International Workshop on Neutrino Telescopes](#). Venice (Italy)

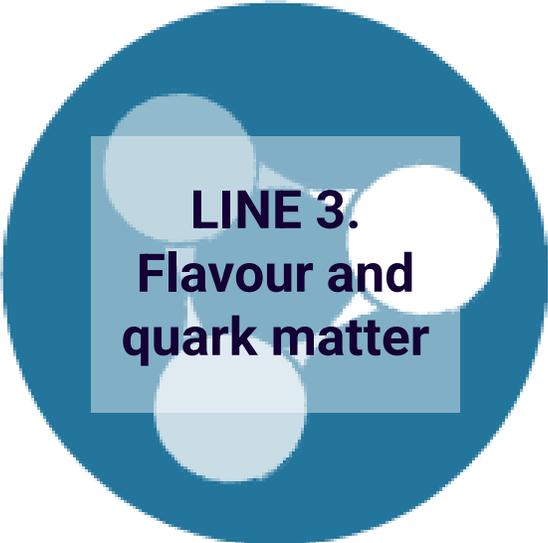
L. Molina Bueno, *New physics searches using ProtoDUNE and the CERN SPS accelerator*, [Searching for long-lived particles at the LHC and beyond: 13th workshop of the LLP Community](#). CERN

P. Novella, *NEXT: first neutrinoless double beta decay searches in gaseous Xe and roadmap towards a ton-scale detector*, [18th International Conference on Topics in Astroparticle and Underground Physics \(TAUP 2023\)](#). Vienna (Austria)

J.W.F. Valle, *The legacy of neutrino oscillations*, [30th International Conference on Supersymmetry and Unification of Fundamental Interactions \(SUSY 2023\)](#). Southampton (United Kingdom)



## ● SCIENTIFIC RESEARCH LINES



### **LINE 3.** **Flavour and quark matter**

The LHCb and ATLAS teams pursue the exploration of the flavour sector, leading several analyses of LHC Run 3 data at CERN. The IFIC theory team applies non-perturbative approaches to QCD (effective field theories and lattice methods) and exploits the complementarity of flavour and collider physics to constrain beyond the Standard Model scenarios. The LHCb experimental groups in collaboration with the theory team have pioneered a feasibility study to measure electric dipole moments of strange and charmed baryons. The interpretation of the newly discovered exotic resonances as tetra or pentaquark states is an area of very active research. The IFIC team leads a novel approach to use heavy hadron decays as laboratories to do spectroscopic studies of new exotic resonances and search for signatures of possible explanations of the anomalies in the flavour sector, such as Leptoquarks and lepton-flavour-violating decays of heavy particles.

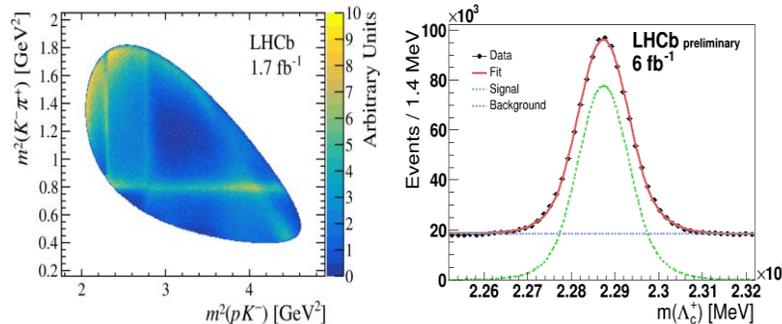
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## L3: FLAVOUR AND QUARK MATTER

### Experiment

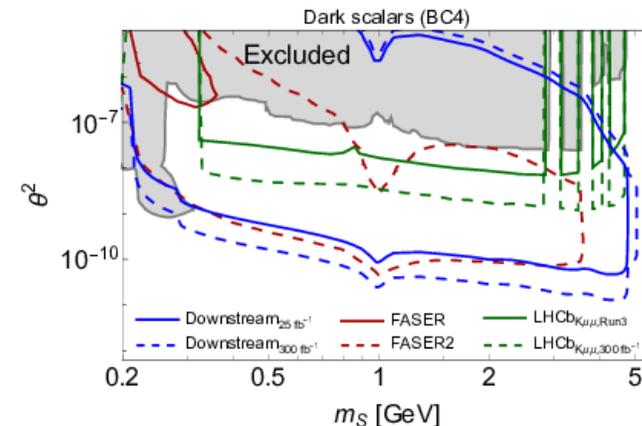
Experimental efforts on flavour and quark matter are pursued through two dedicated experiments, LHCb at CERN and Belle II at KEK, and ATLAS, which is also contributing. During 2023 the groups have been involved in the detector and data acquisition upgrades and operations, but also in the data analysis software and exploitation.

Both the LHC machine and the LHCb experiment had technical problems during 2023. Therefore, the LHCb team has continued its activities of physics analysis focusing on the collected Run 1 + 2 data. These include an updated measurement of the photon polarization from mixing-induced CP asymmetry of the FCNC radiative b-meson decay  $B_s \rightarrow \phi \gamma$ , and measurements of polarization and decay properties of charm baryons produced through weak decays of b-baryons and directly in proton-proton and proton-gas (fixed target) collisions and decaying to multihadron final states with either a proton or a hyperon. All these studies offer a tool for new physics and nonperturbative QCD studies. One such process,  $\Lambda_c^+ \rightarrow \Lambda \pi^+ \pi^-$ , of which LHCb has an unprecedented high-statistics sample, is also being used as laboratory to improve the understanding of excited hyperons and to search for Pentaquark states.



Two examples of the LHCb charm baryon polarization and decay amplitude studies: (left) Dalitz plot for the sample of  $\Lambda_c^+ \rightarrow p K^- \pi^+$  decays, (right) invariant mass distribution of the high-statistics  $\Lambda_c^+ \rightarrow \Lambda \pi^+ \pi^-$  sample.

IFIC researchers are also involved in the LHCb RTA and Trigger system (see L7), playing a leading role on displaced signatures of particles decaying between 30 cm and 7.5 m. The new trigger lines open the possibility for additional physics opportunities, thanks to the significant increase of geometrical acceptance for strangeness decays and feebly interacting particles with long lifetimes. Ongoing physics analyses include  $\Lambda$  hyperon magnetic and electric dipole moment measurements, and searches for dark Higgs scalars, Heavy Neutral Leptons and Hexaquarks.

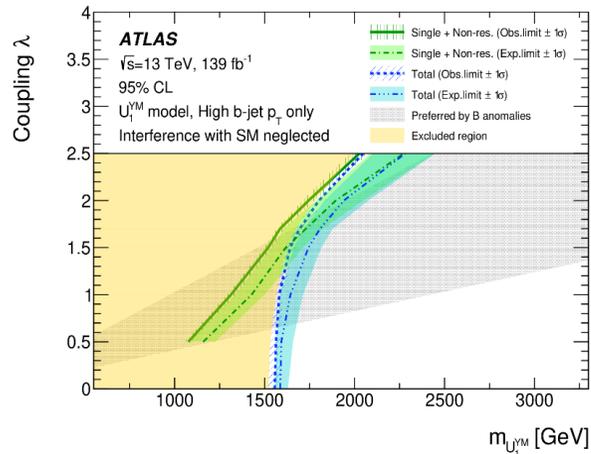


An example of sensitivity enhancement to Higgs-like scalars in  $B \rightarrow K S (\rightarrow \mu\mu)$  decays, using  $S$  decays between 30 cm and about 2 m (Downstream) compared to decays within the LHCb VELO (before 30 cm) and FASER(2). From arXiv:2312.14016 [hep-ph].

The resemblance among generations within various branches poses a significant conundrum within the Standard Model (SM). A possible solution is the postulation of leptoquarks (LQs), hypothetical particles capable of transformations between leptons and quarks. Such a proposition would yield a unified depiction of the fundamental matter particles. LQs would be spin 0 (scalar) or spin 1 (vector) particles, and would interact via the strong force due to their colour charge.

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## L3: FLAVOUR AND QUARK MATTER



The two-dimensional 95% CL exclusion limits in the  $\lambda$ - $m_{LQ}$  plane for singly plus non-resonant produced vector LQ (green lines) and for the sum, referred as Total, of single plus non-resonant plus pair vector LQ production (blue lines), with showing the case with  $\kappa=0$ . Regions to the left of the lines are excluded. The dotted area shows the preferred region where the chosen LQ model can explain observed B anomalies.

The ATLAS Collaboration has studied the full LHC Run 2 dataset (139 /fb) in pursuit of LQs, concentrating on leptoquark interactions involving either a bottom quark or a tau lepton. IFIC researchers derived constraints on LQ mass and coupling parameters by combining signals from both singly and pair-produced leptoquarks. For coupling strengths within the lower range (up to 1), a lower limit on the vector LQ mass at 1.58 TeV was established, assuming Yang-Mills couplings. As coupling

strengths increase (up to 2.5), the significance of single production becomes prominent, extending the lower limit on LQ mass to approximately 2 TeV.

During the long shutdown of the Belle II experiment at KEK, the data collected so far (400 /fb) has been used to report the first evidence for the rare decay  $B^+ \rightarrow K^+ \nu \bar{\nu}$  [arXiv:2311.14647 [hep-ex]], which shows some tension with the SM. The new physics models needed to explain this result also predict an enhancement of  $B^+ \rightarrow K^+ \tau \bar{\tau}$ , a decay IFIC researchers are now searching for in Belle and Belle II. The team is also leading efforts to improve the hadronic B-tagging algorithm, an essential component in these (and many other) missing energy searches.

### Theory and phenomenology

IFIC theorists have made leading contributions to different aspects of flavour and hadronic physics. We have studied final-state interactions in the CP asymmetries of charm-meson two-body decays. Using all available information on meson rescattering and two-channel dispersion relations, the SM prediction for the CP asymmetry in the decay  $D \rightarrow \pi \pi$  has been determined, taking into account the effects from final-state interactions. The result turns out to be much below the LHCb measurement.

We have also studied the role of superallowed transitions in determining the strength of the weak interaction among the lightest quarks

and in searching for new physics beyond the standard electroweak model. Combining the results from all superallowed transitions provides a test of unitarity of the first row of the Cabibbo-Kobayashi-Maskawa matrix, which displays a  $2\sigma$  tension with the SM. A novel orbifold theory has been suggested.

Flavor physics has been also described by a family symmetry that results naturally from compactification and a weakly interacting massive particle dark matter emerges from a Kaluza-Klein excitation. In addition to the "golden" quark-lepton mass relation, the model provides a good global description of all flavor observables.

We have also developed a model that accommodates several flavor anomalies, induces neutrino masses and provides a dark matter candidate. This is achieved by introducing a dark sector contributing to the observables of interest at the 1-loop level. This setup provides a very economical explanation to all these open questions and is compatible with the current experimental constraints.

The Adler function in the Euclidean regime at around 2 GeV has been also determined with three different approaches: dispersion relations based on the hadronic production data in  $e^+e^-$  annihilation, lattice simulations and QCD. The QCD predictions turn out to be in good agreement with the lattice data, while the dispersive results lie systematically below them. The sensitivity of this comparison to  $\alpha_s$  and the precision with which the

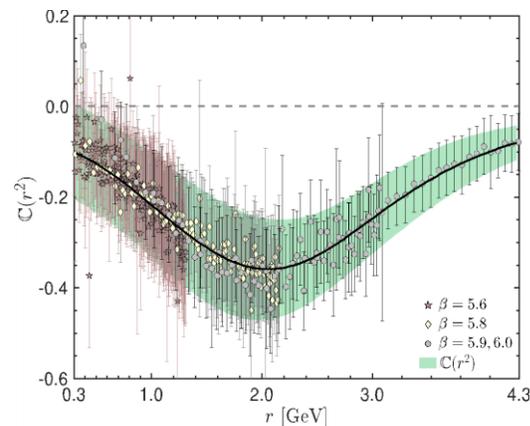
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## L3: FLAVOUR AND QUARK MATTER

renormalisation group equation can be tested is also evaluated.

We have worked on the nonperturbative properties of the fundamental form factors of the three-gluon vertex, using both lattice simulations and continuum methods. We have shown that the characteristic “planar degeneracy” property leads to considerable simplification in all practical applications involving this vertex. Important progress related to the emergence of a mass gap in the gauge sector of QCD through the study of Schwinger-Dyson equations and gauge-fixed lattice simulations has been reported. We have explored how the action of the Schwinger mechanism induces a measurable displacement to the Ward identities satisfied by the three-gluon and quark-gluon vertices, which was confirmed on the lattice.

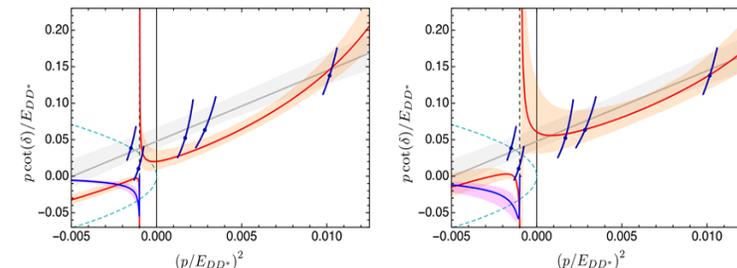
We have also continued our work in the application of AdS/QCD models of hadron structure to the study of hadronic properties and addressed the confinement effects in deep inelastic lepton scattering on nuclei, the so-called EMC effect.



The activation of the Schwinger mechanism hinges on the formation of composite massless poles, which modify the analytic structure of the fundamental vertices of the theory and induce smoking gun displacements in the corresponding Ward identities. This displacement, denoted by  $C(r^2)$ , is obtained using central fits for the lattice data (black solid curve). The green band expresses the uncertainty in this result. The dashed gray line represents the null result, i.e., no Schwinger mechanism.

The activity related to exotic states dynamically generated from the interaction of pairs of charmed heavy-light mesons has been intense, triggered by the discovery of new states by the BES and LHCb collaborations. Of special relevance was the discovery of a charged tetraquark state ( $T_{cc}^+$ ) by LHCb. We have contributed to the discussion on the interpretation of this exotic state and of the mass distribution reported, and predicted its spin and flavor (light and heavy) symmetry partners. We have also discussed the role played by the pion-exchange left-hand cut contributions on the pole extraction from

lattice data.



Fit results to lattice data [M. Padmanath and S. Prelovsek, Phys. Rev. Lett. 129 (2022) 032002] considering the pion-exchange left-hand cut contributions within an effective field theory scheme.

We have worked on femtoscopy correlation functions (CFs) measured in experiments, like ALICE (CERN), where high-multiplicity events are produced in pp, pA, and AA collisions. If the hadron production yields are well described by statistical models, the CFs become sensitive to two-hadron interactions and scattering parameters. CFs are calculated in terms of the spatial overlap between a source function and the square of the absolute value of the wave function of the considered hadron-pair, determined from the half off-shell T-scattering matrix. Thus, CFs provide valuable and complementary access to hadron-hadron dynamics, shedding light on the intriguing nature of some of the numerous light and heavy resonances that have recently been discovered.

We have also calculated the nucleon isovector form factors up to next-to-next-to-leading

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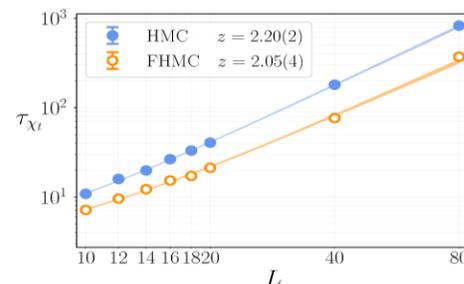
## L3: FLAVOUR AND QUARK MATTER

order by combining relativistic chiral perturbation theory (ChPT) of pion, nucleon, and  $\Delta(1232)$  with dispersion theory. The availability of pion-pion scattering amplitudes obtained with the inverse-amplitude method that describe the corresponding phase shifts in LQCD allow us to extend chiral perturbation theory and study the quark mass dependence of nucleon electromagnetic form factors with the dispersive approach. We specifically address the light-quark mass dependence of the form factors, achieving a good description of recent lattice QCD results. For the Dirac form factor, the combination of ChPT and dispersion theory outperforms the pure dispersive and pure ChPT descriptions. For the Pauli form factor, the combined calculation leads to results comparable to the purely dispersive ones. The anomalous magnetic moment and the Dirac and Pauli radii are extracted.

Lattice Gauge theories provide key input to challenge the SM. On one hand, the SM at low energies is described by an effective theory (QCD+QED) that is strongly coupled. The description of the QCD states prevents the perturbative treatment that allows precise predictions in QED and the electroweak theory. LQCD is a numerical approach to solve QCD in

the strongly coupled regime. It is a key piece in the goal of challenging the SM to a new level of precision: it provides input to many flavor physics processes and also produces the most accurate and precise determinations of the strong coupling constant and quark masses.

Researchers from IFIC have been involved in many such projects of phenomenological interest, but also in more technical aspects. LQCD is based on Monte Carlo sampling, and good algorithms are key to exploit current state of the art HPC facilities and produce solid results. We have been investigating new algorithms for sampling LQCD actions, based on ideas from the Machine Learning (ML) community. This approach, that we call Flow HMC (FHMC), has shown to decrease the required computer time by a factor two, although the scaling is not improved compared with the usual HMC algorithm.



Scaling of the usual HMC algorithm, and our proposal (FHMC), that uses normalizing flows to improve the sampling efficiency. The figure shows the integrated autocorrelation time of the susceptibility at positive flow time. Our proposal shows smaller autocorrelations, which translate in a better statistical precision. On the other hand, both the traditional and our approach show a very similar scaling.

## Selected Publications

R. Aaij et al. [LHCb collaboration], *Amplitude analysis of the  $\Lambda_c^+ \rightarrow pK^-\pi^+$  decay and  $\Lambda_c^+$  baryon polarization measurement in semileptonic beauty hadron decays*, Phys.Rev.D 108 (2023) 1, 012023.

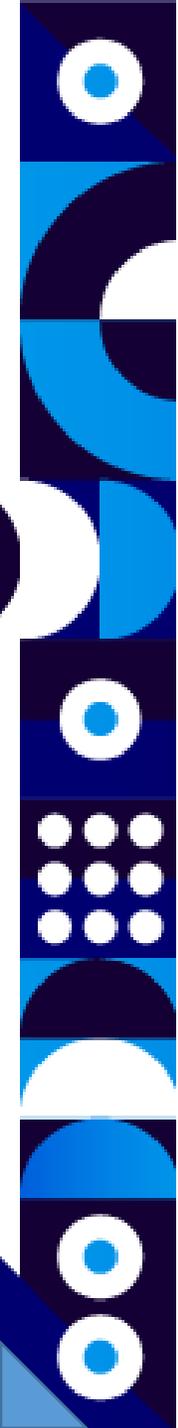
R. Aaij et al. [LHCb collaboration],  *$\Lambda_c^+$  polarimetry using the dominant hadronic mode*, JHEP 07 (2023) 228.

G. Aad et al. [ATLAS collaboration], *Search for leptoquarks decaying into the  $b\tau$  final state in  $pp$  collisions at  $\sqrt{s}=13$  TeV with the ATLAS detector*, JHEP 10 (2023) 001.

M. Davier, D. Díaz-Calderón, B. Malaescu, A. Pich, A. Rodríguez-Sánchez and Z.-Z. Zhang, *The Euclidean Adler function and its interplay with  $[\Delta\alpha]_{\text{QED}^{\text{had}}}$  and  $\alpha_s$* , JHEP 04 (2023) 067

M. N. Ferreira and J. Papavassiliou, *Gauge Sector Dynamics in QCD*, Particles 6 (2023) 312.

M.L. Du, A. Filin, V. Baru, X.K. Dong, E. Epelbaum, F.K. Guo, C. Hanhart, A. Nefediev, J. Nieves and Q. Wang, *Role of Left-Hand Cut Contributions on Pole Extractions from Lattice Data: Case Study for  $T_{cc^+}$* , Phys. Rev. Lett. 131 (2023) 131903



# 5

## L3: FLAVOUR AND QUARK MATTER

### Selected Conference Talks

Luiz Vale Silva, *CKM matrix status in 2023*, 12th International Workshop on the CKM Unitarity Triangle (CKM 2023), Santiago de Compostela, Spain, 18-22 September 2023

Eleftheria Somolonidi, *Final-state interactions in the CP asymmetries of charm-meson two-body decays*, Implications of LHCb measurements and future prospects, CERN, Geneva, Switzerland, 25-27 October 2023

Joannis Papavassiliou, *Emergence of a gluon mass through the Schwinger mechanism*, Parton distribution functions at a crossroad, 18-22 September 2023 - ECT\*, Trento, Italy.

Raquel Molina, *Effective Field Theories for hadron spectroscopy*, 20th International Conference on Hadron Spectroscopy and Structure (HADRON 2023) Genova, Italy, 5-9 June 2023.

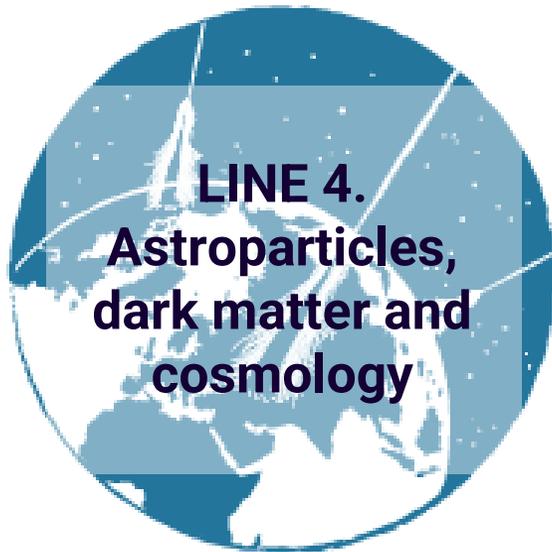
Miguel Albaladejo,  *$J/\psi$  and  $\omega$  decays to  $3\pi$  with Khuri–Treiman equations*, Precision Tests of Fundamental Physics with Light Mesons, 12-16 June 2023- ECT\*, Trento, Italy.

A. Ramos, *Calculational techniques in particle physics: Lattice QCD*, EPS-HEP2023 25 August 2023.



# THE ORIGIN OF MATTER

# SCIENTIFIC RESEARCH LINES



The origin of the matter-antimatter asymmetry in the universe remains an open question. New sources of CP violation are searched for at the LHC by the ATLAS team. On the other hand, the baryon imbalance may be induced by a lepton asymmetry. Such leptogenesis scenarios are tested by IFIC researchers using collider and neutrino data. IFIC is heavily involved in the multi-faceted search for dark matter (DM). IFIC is involved in indirect DM searches within KM3NeT-ARCA, and in LHC searches within ATLAS. IFIC researchers participate in searches for dark mediator decays at NA64 and for neutral and milli-charged long-lived particles at MAPP-MoEDAL, at CERN. The IFIC theory team develops global fits to test DM models exploiting the complementarity of DM, colliders and cosmological measurements. IFIC is involved in the search for axions with RADES and CADEX. Multi-messenger astronomy offers new opportunities to explore transient sources in the Universe, such as the collisions of neutron stars or black holes. IFIC plays a leading role in these searches within KM3NeT-ARCA.

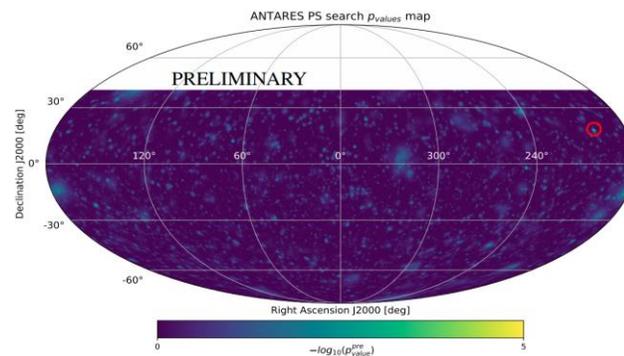
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## L4. ASTROPARTICLES, DARK MATTER AND COSMOLOGY

The research topics of this line include cosmic messengers, especially cosmic neutrinos, dark matter searches and cosmology. IFIC participates in various international collaborations, such as ANTARES/KM3NeT, ATLAS, LHCb, MAPP-MoEDAL, NA64, RAD.ES, babyIAXO and CADEX. It is also involved in the future project MATHUSLA and has an active theory group.

### ANTARES/KM3NeT

After the dismantling of ANTARES in early 2022, now it is time to wrap up and produce the final results of ANTARES. In that regard, one of the most important results, with IFIC at the leading role, was the search for sources of high-energy cosmic neutrinos, both time-integrated and time-dependent. Members of the VEGA group have produced the preliminary results of that search that has been presented at the International Cosmic Ray Conference (ICRC). Even if no significant detection was found, there have been several interesting upper fluctuations. At the same time, a time-dependent search of this source shows a neutrino candidate compatible with a neutrino flaring event observed by IceCube.



Sky map, in equatorial coordinates, with pre-trial p-values from the cosmic neutrino source search with the ANTARES full dataset. The red circle indicates the most significant spot in the sky.

Regarding KM3NeT, the detector construction is accelerating. In particular, the high-energy configuration (TeV-PeV energies), ARCA, is already taking data with 28 detection units and more than 40, out of the 230 in total, are expected to be operational during the spring of 2024.

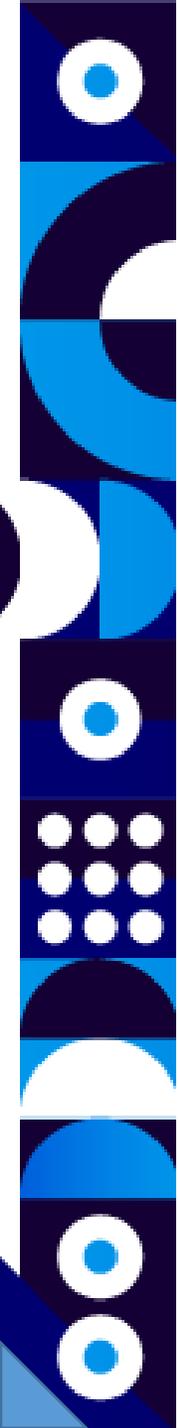
We have several members of the VEGA group at IFIC leading multi-messengers searches in KM3NeT. Among the recent astrophysical events, one of the most interesting ones is the brightest Gamma-Ray Burst (GRB221009A) which happened in 2022. The analysis of the possible emission of neutrinos detected by KM3NeT in spatial and temporal coincidence was also led by VEGA group members. The group also is deeply involved in the development of the "Online Framework" of

KM3NeT, in charge of selecting and analyzing interesting alerts provided by other experiments and also, in the near future, will be capable of sending interesting neutrino candidates to other observatories for follow up.

The VEGA group at IFIC is also involved in searching signatures of physics beyond the Standard Model expectations in neutrino data (see, e.g., [P1]). All these results concerned analyses of real data using the most up-to-date data sets, and were shown at the ICRC2023 conference. Indirect searches for a dark matter signal from the Galactic Centre using neutrinos were presented. Moreover, a novel analysis has studied the first data recorded with KM3NeT/ORCA looking for effects of quantum decoherence in neutrino oscillations.

### ATLAS and MATHUSLA

The IFIC ATLAS team has led searches for CP violation in top and Higgs interactions and constraints on the Higgs self-coupling that encodes properties of the electroweak phase transition, inputs which could be important in the context of understanding the matter-antimatter asymmetry in the Universe. IFIC researchers have been actively completing the final result with Run 2 on the search for the self coupling of the Higgs boson in the final state with two b-jets and two photons as well



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## L4. ASTROPARTICLES, DARK MATTER AND COSMOLOGY

as its interpretation in terms of beyond Standard Model effective field theory operators. They are also deeply involved in the search for dark matter produced in association with a top quark in final states containing a single top quark and an energetic W-boson or searches for events with one top quark and missing transverse momentum. The IFIC - ATLAS group is also leading dedicated searches for long-lived particles like the search for a displaced jet in the ATLAS calorimeter in association with SM W/Z bosons, aiming at scenarios with long-lived Axion-like Particles for the first time in ATLAS. These analyses searching for BSM models are ongoing and expected to be published in Spring/Summer 2024.

Furthermore, in 2023, two ATLAS Run-2 analyses looking for supersymmetric (SUSY) particles in events with two electrons or muons were published. The opposite-sign leptons search not only targets leptonically decaying Z bosons, manifested as a Z mass peak in the dilepton invariant mass spectrum, but also kinematic “edges” resulting from SUSY particle cascade decays, going beyond the conventional path of SUSY searches.

The (orthogonal) search for same-sign leptons

yielded sensitivity in a, so-far unexplored, natural model of R-parity violating supersymmetry with bilinear terms (bRPV) characterized by light, mass-degenerated higgsinos. SUSY bRPV terms induce neutrino masses and mixing, thus offering a unique connection between collider searches for New Physics and neutrino-oscillation experiments.

### MAPP-MoEDAL

IFIC has a leading position in MoEDAL, an experiment designed to search for manifestations of new physics through highly ionizing particles produced at the LHC. MoEDAL is the sole contender in searches for highly charged magnetic monopoles, has carried out the sole dyon search in accelerator experiments and the first search for monopoles produced via Schwinger mechanism. It has constrained high-electric charge objects (HECOs) with extremely high charges. The IFIC team is coordinating the physics analyses and other aspects of the experiment and is strongly involved in the development and testing of key theoretical scenarios. A recent example comes from the application of resummation schemes in HECO production, thus improving mass limits set by ATLAS and MoEDAL.

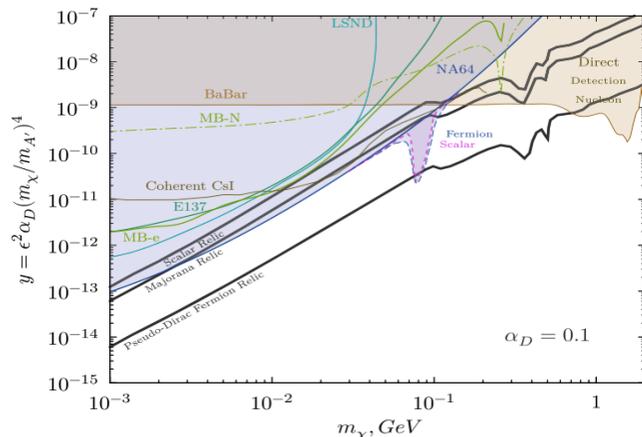
In addition, the MoEDAL Apparatus for Penetrating Particles (MAPP) will extend the MoEDAL physics program to feebly interacting, long-lived messengers of dark matter scenarios and neutrino portal models.

### NA64

NA64 is a fixed target experiment testing New Physics using e-/e+, muon and hadron beams at CERN SPS. In 2022, the experiment multiplied its data by three times being background free. In 2023, we contributed to the 2022 analysis, being part of one of the blinded data analyses carried out. The latest results using the 2016-2022 statistics, corresponding to  $9.37 \times 10^{11}$  electrons on target (EOT), set the strongest Light Dark Matter (LDM) limits for masses below 350 MeV, being PRL editor's suggestion [P2]. For the first time, the experiment started to probe the parameter space suggested by the LDM models. We also wrote the EP Newsletter of June 2023 summarizing this achievement [O1]. In 2023, NA64 increased its total statistics to  $1.5 \times 10^{12}$  EOT with an improved setup to further improve the overall experiment performance and the background rejection. The first physics analysis for the first Dark sector searches with positron and muon beam were also completed. IFIC is one of the leaders of the muon analysis. This year, the experiment also increased the muon statistics to  $1.5 \times 10^{11}$  MOT with a significantly improved setup. IFIC is currently performing the analysis of this data. Finally, L. Molina was responsible for writing the 2023 annual NA64 SPSC report summarizing the status of the experiment [P2] and presented the latest results of the experiment in the Light Dark World 2023 workshop.

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The NA64e exclusion limit for Light Dark Matter searches with  $\alpha_D=0.1$  and  $m_A=3m_\chi$  using the 2016-2022 statistics corresponding to  $9.37 \times 10^{11} \text{EOT}$ . The constraints from other experiments are also shown.

### RAD.ES, babyIAXO and CADEX

The AITANA group also works on the electromagnetic analysis and design of haloscopes for the search of dark matter axions. Following the inverse Primakoff effect, haloscopes are microwave resonators immersed in a high magnetostatic field region. Different microwave frequency regions are being explored, associated with three different international collaborations: RAD.ES (X-band, around  $35 \mu\text{eV}$ ), babyIAXO (L and C bands, around  $1 \mu\text{eV}$ ) and CADEX (W-band, around  $400 \mu\text{eV}$ ) which might allow detecting axions

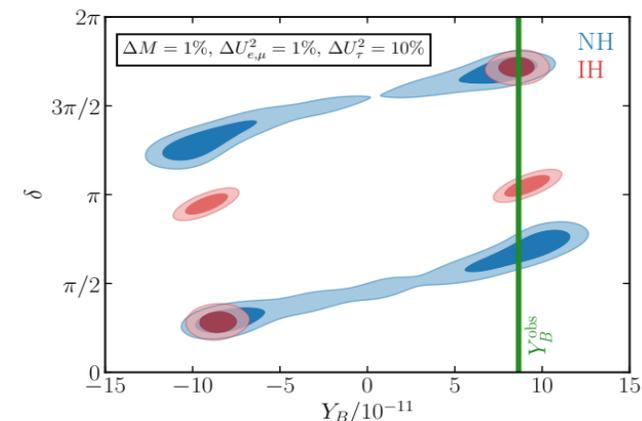
with different masses. These microwave resonators can also be used for the detection of high frequency gravitational waves based on the inverse Gertsenshtein effect. Numerical techniques based on full-wave modal analysis and commercial software have been implemented for very efficient and accurate simulations, exploring the search of both dark matter axions as well as gravitational waves.

### THEORY

As a joint theoretical and experimental research center, the theoretical research at IFIC is directly connected to the active experimental projects. In this regard, we can highlight our studies of different dark matter candidates, exploration of leptogenesis scenarios for the generation of the matter-antimatter asymmetry of the Universe, and production of LLPs at colliders and astrophysical sources.

As an example, we mention several works along these lines. In [P4], neutrino masses arising from the exchange of dark matter states were analyzed in the context of the singlet-triplet scotogenic model. The case of a singlet-like fermionic dark matter candidate was explored, studying all the relevant constraints and the prospects for direct dark matter detection in upcoming experiments. Other works, completed in 2023, with fermionic dark matter candidates from a dark sector are Phys. Rev. D 108 (2023) 5, 055001, or from strongly interacting dark sectors,

JHEP 01 (2024) 034. Another interesting possibility is that of dark matter being formed by primordial black holes, as explored in [C4, C5]. Even if they do not constitute all of the dark matter, 21 cm radio observations are very powerful to constrain this possibility.



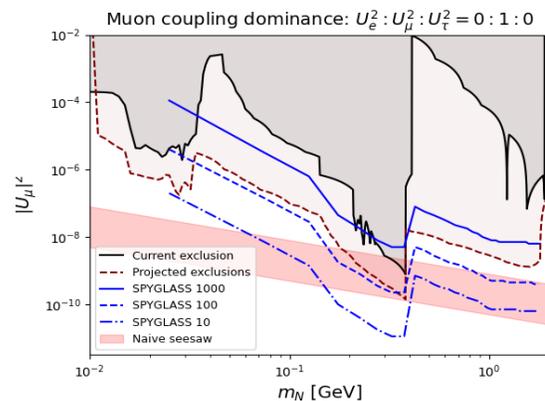
Measurement of CP violation in neutrino oscillations, HNL masses and mixings with electron, muon and tau flavors can suffice to pin down matter-antimatter asymmetry from laboratory measurements.

Regarding leptogenesis scenarios, the minimal type I seesaw model, augmented with only two heavy Majorana singlets, provides a natural explanation for the matter-antimatter asymmetry when the masses of these singlets fall within the GeV range [P5]. In a minimal model with degenerate singlets, CP flavor invariants were used to obtain analytical approximations to the asymmetry and derive bounds on right-handed neutrino parameters with observable implications for future

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L4. ASTROPARTICLES,  
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experiments. Another research line, on Beyond Standard Model physics, is dark sector models with LLPs. In [P6] we studied how LLPs produced from heavy mesons decays originating in cosmic rays can help to probe the parameter space of a sterile neutrino in the (sub)-GeV range, while proposing a satellite experiment that would probe unexplored heavy neutral lepton (HNL) parameter space for the cases of dominant couplings to electrons, and also to muons. Additionally, we have completed works exploring the interplay between astroparticles and cosmology, such as the elusive puzzle of dark energy [C6].



Constraints on HNL couplings to muons with the particle detector satellite SPYGLASS, for different energy thresholds (blue curves). The gray (brown) area is the current (future) sensitivity.

## Selected Publications

[P1] A. García-Soto, D. Garg, M. H. Reno and C. A. Argüelles, “Probing quantum gravity with elastic interactions of ultrahigh-energy neutrinos”, [Phys. Rev. D 107, 033009 \(2023\)](#).

[P2] Y. M. Andreev et al. [NA64], “Search for Light Dark Matter with NA64 at CERN”, [Phys. Rev. Lett. 131 \(2023\) no.16, 161801](#). Editor’s suggestion.

[P3] J. M. García-Barceló et al., “On the development of new tuning and inter-coupling technology using ferroelectric materials in the detection of dark matter axions”, [IEEE Access 11, 30360-30372, 2023](#).

[P4] A. Karan, S. Sadhukhan, J.W.F. Valle, “Phenomenological profile of scotogenic fermionic dark matter”, [JHEP 12 \(2023\) 185](#).

[P5] S. Sandner, P. Hernandez, J. Lopez-Pavon, N. Rius, “Predicting the baryon asymmetry with degenerate right-handed neutrino”, [JHEP 11 \(2023\), 153](#).

[P6] O. Fischer, B. Pattnaik, J. Zurita, “Testing heavy neutral leptons in cosmic ray beam dump experiments”, [JHEP 07 \(2023\) 193](#).

## Selected Conference Talks

[C1] A. Sánchez Losa, [“Neutrino Astronomy news from the Mediterranean Sea”](#), L International meeting on Fundamental Physics, Santander (Spain), October 2-6, 2023, Invited talk.

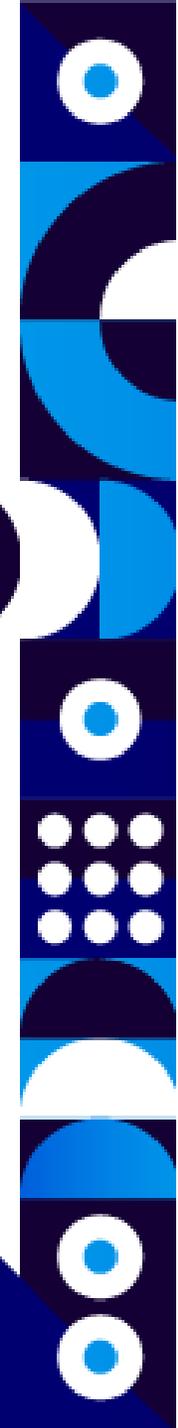
[C2] V. A. Mitsou for the MoEDAL Collaboration, “MoEDAL-MAPP - Detectors specialised for LLP searches,” LHCP 2023 – Large Hadron Collider Physics Conference, Belgrade (Serbia), May 22-26, 2023.

[C3] L. Molina Bueno. [“Latest results from the NA64 experiment”](#), Light Dark World 2023, Karlsruhe (Germany), September 19-21, 2023. Invited plenary talk.

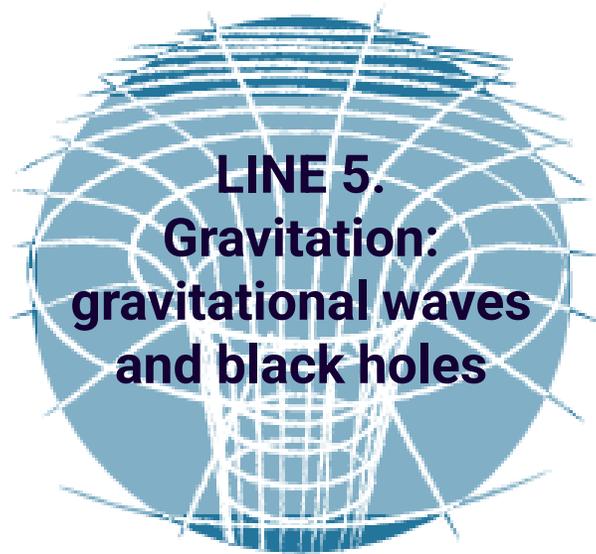
[C4] S. Palomares-Ruiz, [“Primordial black holes and the 21cm line”](#), 57th Rencontres de Moriond EW 2023, March 18 - 25, 2023, La Thuile (Italia). Invited plenary talk.

[C5] Valentina De Romeri, [“Signatures of primordial black hole dark matter at DUNE and THEIA”](#), New Horizons in Primordial Black Hole physics (NEHOP) Naples (Italy), June 19-21, 2023.

[C6] O. Mena, [“Interacting dark energy scenarios and cosmological tension”](#), COSMO 2023, IFT Madrid (Spain), September 11-15, 2023.



## SCIENTIFIC RESEARCH LINES



IFIC team explores fundamental physics with gravitational waves (GWs) and new cosmological measurements. IFIC researchers are members of the ESFRI project SKA, the largest radio telescope that aims to map the 21cm line, and play a leading role in defining its fundamental physics case. The discovery of primordial GWs created by quantum effects at the very earliest instants of the universe or of a stochastic GW background that might have originated from post-inflationary preheating, first order phase transitions, or cosmic string networks, would be a spectacular discovery of physics beyond the Standard Model of particle physics. IFIC plays a leading role in the modelling and search for a primordial stochastic GW background in future GW detectors such as LISA and Einstein Telescope. IFIC groups study the detailed gravitational-wave ringdown of colliding black holes, expected to be tested in future GW detectors, as probes of physics beyond general relativity and of quantum effects in gravity.

## 5 L5. GRAVITATION: GRAVITATIONAL WAVES AND BLACK HOLES

The research topics of this line include the theory and detection of gravitational waves (GWs) and their interaction with matter, quantum aspects in gravity, black holes and theories beyond General Relativity. Members of L5 are involved in international collaborations, like the Laser Interferometer Space Antenna (LISA) and the Einstein Telescope (ET), which represent the will-be first space-base and next generation of ground-based GW detectors, respectively, that will start taking data by mid 2030's. Members of L5 also aim to study the interface between gravity and quantum field theory in cosmological and black hole scenarios, analog models of gravity, and supersymmetry among others.

### Gravitational wave backgrounds (GWBs)

A major L5 research line is the study of GWBs as a probe of high-energy physics and early universe cosmology. In [L5.1] we explored how light primordial black holes, which evaporate before the onset of Big Bang nucleosynthesis, can dominate the universe's energy density. We studied how such an early era can be probed using gravitational waves (GW) emitted by local and global cosmic strings. In

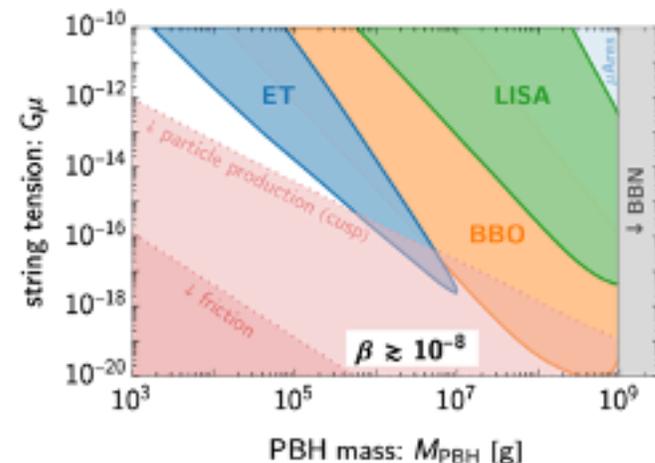
[L5.2] we reviewed the cosmology related objectives of the Laser Interferometer Space Antenna (LISA), which recently passed the "adoption" phase. IFIC personnel are involved primarily in studying stochastic gravitational backgrounds and their implications for early-universe cosmology and particle physics, including Inflation, first order phase transitions, cosmic strings, and tests of non-standard pre-Big-Bang nucleosynthesis cosmology.

### Quantum field theory in curved spacetime

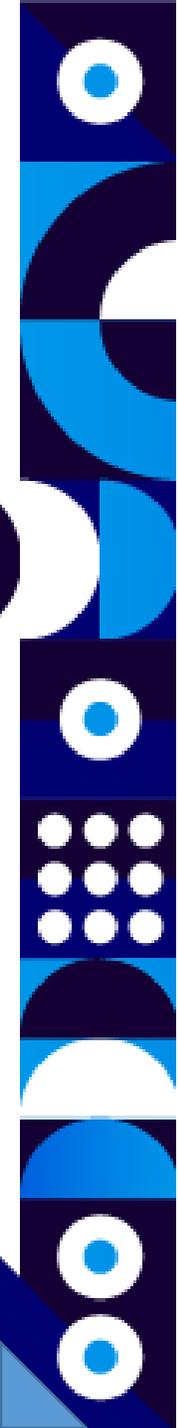
The study of quantum fields in a gravitational field, including the associated experimental branch known as analogue-gravity, is a major and long-standing research topic of L5 that dates back to the early 2000. In [L5.3] three members of our group have continued this research line by computing quantum corrections to classical black holes in General Relativity and its imprints in the ringdown of gravitational-wave detections.

### Modified theories of gravity.

The study of quantum fields in a gravitational field, including the associated experimental branch known as analogue-gravity, is a major and long-standing research topic of L5 that dates back to the early 2000. In [L5.3] three members of our group have continued this research line by computing quantum corrections to classical black holes in General Relativity and its imprints in the ringdown of gravitational-wave detections.



Reaches of the GW observatories for detecting light PBH of mass  $M_{\text{PBH}}$  assuming the local cosmic strings of tension  $G\mu$ , i.e., those formed at phase transition of energy scale  $10^{14} \times \sqrt{G\mu/10^{-10}}$  GeV.



# 5

## L5. GRAVITATION: GRAVITATIONAL WAVES AND BLACK HOLES

### Selected Publications

[L5.1] *"Primordial black hole archaeology with gravitational waves from cosmic strings"* A. Ghoshal (Warsaw U.), Y. Gouttenoire (Tel Aviv U.), L. Heurtier (Durham U., IPPP), P. Simakachorn (Valencia U.-IFIC). JHEP 08 (2023) 196. [DOI](#) [\[arXiv\]](#).

[L5.2] *"Cosmology with the Laser Interferometer Space Antenna"* LISA Cosmology Working Group with D. G. Figueroa (IFIC) and P. Simakachorn (DESY - Hamburg U.). Living Rev.Rel. 26 (2023) 1, 5. [DOI](#) [\[arXiv\]](#)

[L5.3] *"Quantum corrections to the Schwarzschild metric from vacuum polarization"*. P. Beltrán-Palau (Valencia U. - IFIC), A. del Río (Valencia U. - IFIC), J. Navarro-Salas (Valencia U. - IFIC). Phys. Rev. D. 107 (2023) 085023 [DOI](#) [\[arXiv\]](#)

[L5.4] *"Landau damping for gravitational waves in parity-violating theories"*. F. Bombacigno (Valencia U. - IFIC), S. Boudet, F. Moretti, G. J. Olmo (Valencia U. - IFIC). JCAP 02 (2023) 009. [DOI](#) [\[arXiv\]](#)

### Selected Conference Talks

J. Navarro-Salas, "Black holes, quantum fields, and fundamental physics", Invited Talk, at 4th European Physical Society Conference on Gravitation: Black Holes Valencia, 14-November-2023.

Daniel G. Figueroa, "Numerical Applications in Cosmology", Invited talk at Ending Inflation and the Hot Big Bang, 5-9 June 2023, Simons Center, Stony Brook, US

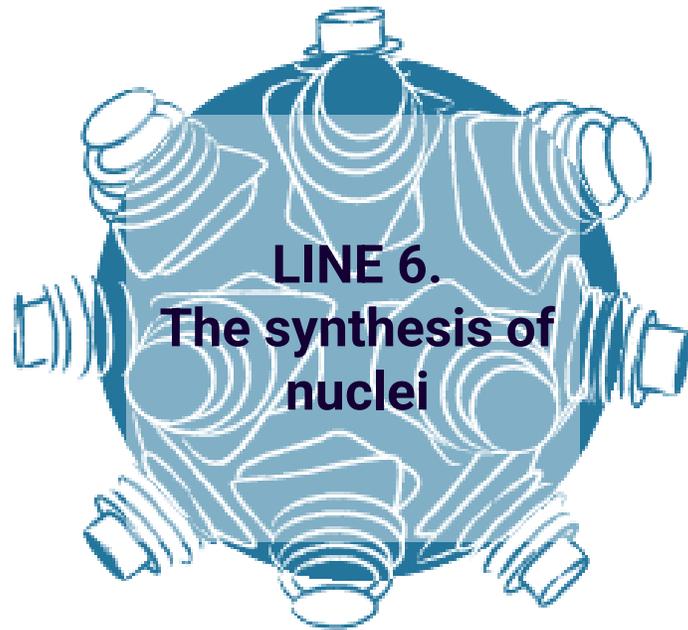
Daniel G. Figueroa, "Cosmological Gravitational Waves", Plenary Talk at COSMO 2023, 11-15 Sept. 2023, at IFT, Madrid Spain

F. Bombacigno, "Exploring Chern-Simons gravity from a metric-affine perspective: black holes, cosmology and gravitational waves" Keynote talk at EREP 2023, Bilbao, July 18th 2023

G. J. Olmo, "Gravitational collapse and exotic compact objects beyond GR", Invited talk at III Encontro de Primavera da SBF, 26-29 Sept. 2023, Niterói (Brasil)

G. J. Olmo, "Baby universes and wormhole mimickers", invited talk at 7th UICPAM-2023, 4-5 Dec. 2023, (online)

## SCIENTIFIC RESEARCH LINES



The recent observation of gravitational waves from a merger and the associated electromagnetic emission has led for the first time to the "in vivo" observation of the synthesis of heavy elements. Nuclear physics input from very neutron-rich exotic nuclei is required to pin down the complex processes taking place in those events. The experimental nuclear physics group at IFIC leads measurements of the decay properties of key nuclei at RIKEN (Japan), GSI (Germany), JYFL (Finland), and n\_TOF and ISOLDE (CERN). On the other hand, it is known that about 50% of the heavy elements in the Universe originate instead in neutron-induced reactions in red-giant stars on a much longer timescale. The HYMNS project has built an innovative instrument, i-TED, to carry out measurements of key stellar nucleosynthesis reactions in the s-process at n\_TOF at CERN. IFIC is also co-leading the AGATA array project, which aims to be the most precise position-sensitive high-resolution gamma detector array for nuclear structure studies.

# 5

## L6: THE SYNTHESIS OF NUCLEI

### EXPERIMENTAL NUCLEAR PHYSICS

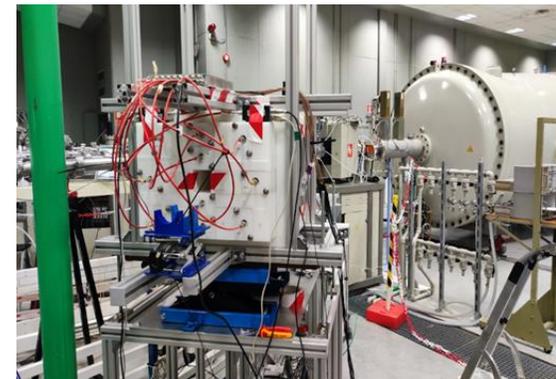
The experimental Nuclear Physics activity at IFIC is carried out by two groups, the AGATA group focussed in in-beam gamma spectroscopy, and the Gamma and Neutron Spectroscopy group. The research of both groups covers aspects of nuclear structure, astrophysics, applications and the development of instrumentation.

In 2023, one important result of the Gamma and Neutron Spectroscopy Group is related to the study of beta decays close to the proton dripline. In the invited article [1] we report on recent experimental results on beta decays of  $Z = N + 2$  parent nuclei into self-conjugate ( $N = Z$ ) nuclei with mass number  $58 \leq A \leq 70$ . Starting from a  $J^\pi = 0^+$  parent state, these cases undergo super-allowed beta decays preferably to the isobaric analogue state through so-called Fermi transitions and to  $J^\pi = 1^+$  states by way of Gamow-Teller (GT) transitions. The operator of the latter decay is a generator of Wigner's  $SU(4)$  algebra and as a consequence GT transitions obey selection rules associated with this symmetry. Since  $SU(4)$  is progressively broken with increasing

mass number ( $A$ ), mainly as a consequence of the spin-orbit interaction, this symmetry is not considered relevant for heavier nuclei. In [1] we argue, however, that the pseudo-spin concept can be very useful in this context. In nuclei with  $58 \leq A \leq 70$  the pseudo-spin-orbit splitting can be small, so nuclear states can exhibit an approximate pseudo- $SU(4)$  symmetry. To test this conjecture, the GT decay strength was calculated with a schematic Hamiltonian with pseudo- $SU(4)$  symmetry and compared with the experimental results obtained by our group. The experimentally observed GT strength indicates a restoration of pseudo- $SU(4)$  symmetry for the  $A = 70$  system.

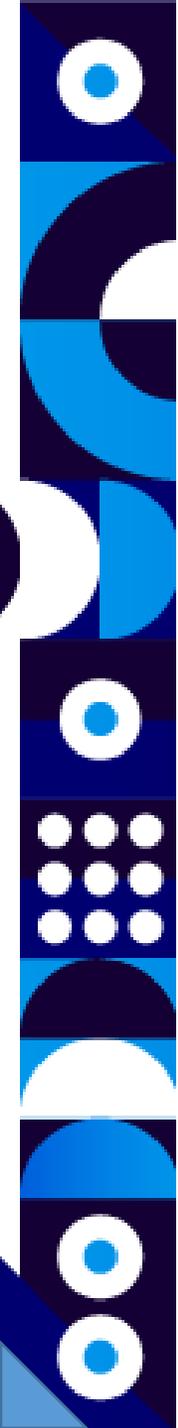
The study of beta decays is of relevance in other fields. In this context an important contribution in 2023 is the realization of measurements of the shapes of the beta spectrum for decays that are selected for their impact on the calculations of the antineutrino spectrum in reactors using radioactive beams of high isotopic purity. Surprisingly, the shapes of forbidden beta decays are not at all well known. For these studies a new detector system has been developed in collaboration with Subatech (France) and Univ. of Surrey (UK). The measurements were performed at the IGISOL IV facility of the Univ. of Jyväskylä (Finland). The relevance of the measurements was recognized with a photo of the setup selected as the cover-page of the Univ. of Jyväskylä Annual Report. This line of research

can be also relevant in the future for fundamental applications.



Experimental setup at CMAM with the miniBELEN-10A detector on the foreground and the 5MV tandem accelerator behind it.

As in the earlier case, the group is involved in the continuous development of instrumentation. The miniBELEN-10A detector is a modular and transportable neutron counter with a nearly flat detection efficiency up to 8 MeV. It is one of the detection systems available for the MANY collaboration (Measurement of Alpha Neutron Yields and Spectra), a Spanish project aimed at conducting measurements of  $(\alpha, n)$  reactions. The design and commissioning of this setup have been led by the Gamma and Neutron Spectroscopy group. An important achievement in 2023 was the measurement of the  $^{27}\text{Al}(\alpha, n)^{30}\text{P}$  cross-section at CMAM in Madrid, derived from thick target yields for alpha energies from near the reaction threshold up to 8 MeV. This marks the first



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## L6: THE SYNTHESIS OF NUCLEI

physics measurement in the MANY program and the first time this cross-section has been measured across a wide range of alpha energies using a single instrument.

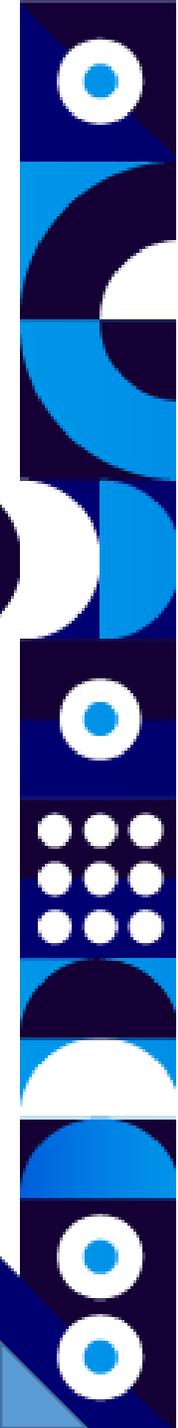
In 2023, the CERN n\_TOF team at IFIC made significant strides in the data analysis of two pivotal reactions crucial for stellar nucleosynthesis: the s-process branchings  $^{79}\text{Se}(n,\gamma)$  and  $^{94}\text{Nb}(n,\gamma)$ , conducted within the framework of the HYMNS ERC Consolidator Grant [2]. Drawing from this valuable experience, the IFIC team at CERN n\_TOF is currently spearheading three new experiments aimed at the future measurement of various s-process neutron-capture reactions.

With the recent recruitment of D. Cortina, new studies of nuclear reactions induced by unstable nuclei at relativistic energies have been initiated in connection with the R3B experiment of the international facility FAIR. These studies provide a complementary tool for gaining a deeper knowledge of the structure and dynamics of the atomic nuclei relevant to our understanding of the origin of the heavy elements in the universe.

The main activities of the AGATA group in 2023 have been the contribution to the construction of the array, reported in the instrumental section, and the realization of experimental nuclear structure studies with AGATA as well as other large arrays for high resolution spectroscopy. During the first semester the experimental activity with AGATA was focused mainly on studies using multi-nucleon transfer reactions with the AGATA-PRISMA setup. The coupling of the highly efficient tracking sub-array of AGATA installed at INFN-LNL and the high acceptance magnetic spectrometer PRISMA is a unique world-class set-up for such studies, in particular for the determination of transition probabilities. PRISMA, in addition to determine A and Z of the binary reaction products, is able to determine the ejectile trajectories, providing fundamental information for the Doppler correction advanced capabilities of AGATA (see Ref. [3]).

Relevant results published in 2023 come from the previous campaign with the ISOL radioactive ion beams from SPIRAL/GANIL, Caen France, including in the set up the first implementation of GRIT (with contribution from IFIC), AGATA and the magnetic spectrometer VAMOS++. Our results in exotic light nuclei are contributing to benchmarking ab-Initio nuclear structure models, in particular the contribution of effective three body forces (see Ref. [4]).

There are also contributions to theory in this line. Contribution [5] describes proposed particle physics activities for the European Spallation Source (ESS), as well as their place in the current theoretical landscape. This facility, presently under construction in Lund, Sweden, will be the world's brightest neutron source. The neutrons and neutrinos produced at the ESS will enable high precision (sensitivity) measurements (searches), which are analysed in detail in this work. Contribution [6] reviews the role of superallowed transitions in determining the strength of the weak interaction among the lightest quarks and in searching for new physics beyond the standard electroweak model. The two sets of superallowed decays in nuclei considered here are pure Fermi and mirror transitions. Combining the results from these measurements, which are fully consistent, provides a test of unitarity of the first row of the Cabibbo-Kobayashi-Maskawa matrix, which displays a  $2\sigma$  tension with the standard model.



# 5

## L6: THE SYNTHESIS OF NUCLEI

### Selected Publications

[1] P. Van Isacker, A. Algora, A. Vitéz-Sveicz, G. Kiss, S. E. A. Orrigo, B. Rubio and P. Aguilera, *Symmetry* 15, 2001 (2023). [DOI](#)

[2] C. Domingo-Pardo et al., Advances and new ideas for neutron-capture astrophysics experiments at CERN n\_TOF, *The European Physical Journal A*, Volume 59, Issue 1, article id. 8 (2023). [DOI](#)

[3] R. M. Pérez-Vidal et al. “Nuclear structure advancements with multi-nucleon transfer reactions”, *European Physical Journal A* 59, 114 (2023). [DOI](#)

[4] I. Zanon et al. “High-Precision Spectroscopy of 200 Benchmarking Ab Initio Calculations in Light Nuclei”, *Physical Review Letters* 131, 262501 (2023). [DOI](#)

[5] H. Abele et al., “Particle Physics at the European Spallation Source”, *Phys. Rept.* 1023, 1-84 (2023). [DOI](#)

[6] A. Falkowski, M. Gonzalez-Alonso, O. Naviliat-Cuncic, N. Severijns, “Superallowed decays within and beyond the Standard Model”, *Eur. Phys. A* 59, 113 (2023). [DOI](#)

### Selected Conference Talks

J. Lerendegui-Marco et al., Recent highlights and prospects on  $(n,\gamma)$  measurements at the CERN n\_TOF facility. Invited Talk. [17th International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics](#). Institut Laue Langevin, 17-21 July 2023, Grenoble, France.

A. Algora et al., Shape effects and the search for pn pairing in the A=70 region. Invited talk. [International Conference on Proton-Emitting Nuclei](#), June 25 - 30, 2023, Warsaw, Poland.

A. Gadea, R.M. Perez Vidal, Lifetimes measurements with MNT reactions at the AGATA-VAMOS++ setup: Exploring the seniority conservation in the N=50 semimagic nuclei above Z=40. Invited talk. [Colloque GANIL 2023](#), 25–29 September 2023, Soudans, France.

M. Gonzalez-Alonso, Beta decays within and beyond the Standard Model. Invited seminar. [ISOLDE seminar](#), CERN, Geneva (Switzerland) (October 10th, 2023)



# ADVANCED INSTRUMENTATION AND COMPUTING

# SCIENTIFIC RESEARCH LINES



IFIC's goals include the construction and commissioning of cutting-edge instruments where we have taken a major in-house responsibility. Several construction projects are particularly strategic for the institute in the coming years: the upgrades of the LHC experiments (ATLAS and LHCb), the construction of NEXT-100, the development of new instruments for nuclear physics (i-TED and AGATA), for super B-factories (Belle II) and for Higgs factories (ILC, CLIC). The KM3NeT neutrino telescope has deployed already 18 lines, and a huge increase in the deployment is expected during the coming years. The neutrino team is also involved in the construction of the DUNE detectors at SURF, and of their large-scale demonstrators at CERN. In computing, the Spanish ATLAS Tier-2 focuses on the needs for LHC Run3 and the preparations for the HL-LHC within the WLCG (Worldwide LHC Computing GRID) program, including the usage of HPC resources, the ATLAS Event Index, Core Computing tasks and Physics Analysis applying ML.

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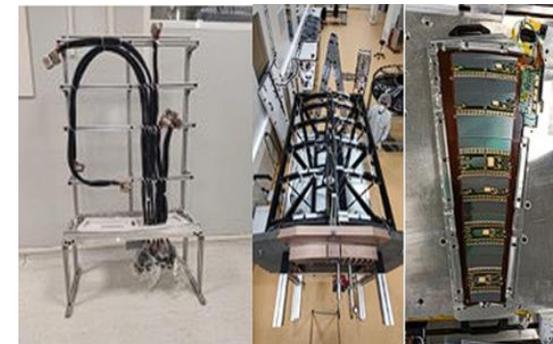
## L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

### ATLAS, LHC

IFIC is involved in the operation and calibration of the ATLAS detector, with commitments in the alignment of the inner detector, the trigger system, and in the reconstruction and calibration of electrons, muons and jets in the experiment. An innovative approach has been introduced in the alignment to correct for potential charge-dependent momentum biases, using the  $Z \rightarrow \mu^+ \mu^-$  resonance. Changes in the track identification software have been made to maintain the tracking performance under the increased luminosity and harsher pile-up environment of the LHC in Run 3. IFIC is involved in the electron reconstruction within ATLAS, exploiting deep neural networks to enhance the discrimination between prompt electrons and fake/non-prompt electrons. The IFIC ATLAS group was involved in the in-situ calibration of the jet energy scale using events where a jet recoils against a photon. In the ATLAS flavour tagging group, IFIC has contributed to the development of a new algorithm to identify boosted Higgs decays to bottom and charm

quarks that relies on transformer neural networks. This algorithm is key to measurements of the bottom and charm Yukawa couplings. IFIC has participated in the operation of the ATLAS trigger system throughout 2023. The group has been involved in the trigger software validation, trigger menu configuration and tau lepton trigger identification performance studies. During 2023, most of the upgraded phase-I Level-1 trigger system has been successfully commissioned.

IFIC is one of the main actors in the upgrade of the ATLAS detector for the LHC high luminosity phase in two of the subsystems: the central hadronic calorimeter (TileCal) and the microstrip silicon detector system in the Inner Tracker (ITk). The teams at IFIC have relevant responsibilities on the readout electronics of the calorimeter and in the construction and assembly of the charge particle tracker. The TileCal preprocessor (TilePPR) design, responsibility of IFIC, has been finalized. The group at IFIC is testing the final prototypes: beam test campaigns, thermal and stress testing. The ITk project at IFIC is already in production mode on all fronts. The focus is the service module that brings power, cooling and optical fibers for controls signals and data extraction to the detector modules, as well as module assembly, local support structures (petals), and petal loading.



ATLAS ITk upgrade: connectorized cables in the service module (left), service module assembled into the mock-up of the global structure used for the system tests (center) and pre-production petal loaded with 9 modules on each side (right).

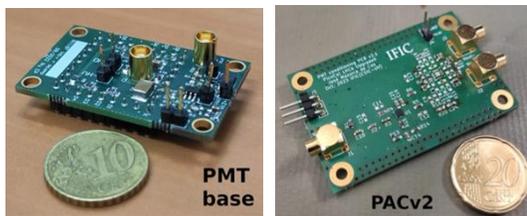
### LHCb and TWOCRIST PoP

The pioneering Real Time Analysis (RTA) and Trigger system of the new LHCb detector opens the possibility to trigger on tracks as far as 7 m away from the interaction point. IFIC is playing a major role in the design and implementation of new algorithms. Looking beyond, for Run 4, steady R&D for deploying an FPGA-based HLT1 system for SciFi (RETINA) has continued. IFIC also participates in the new LHCb electromagnetic calorimeter. Main IFIC's responsibilities include the design of the energy ASIC using TSMC 65 nm CMOS technology, and the amplifier and shaper circuit included on the photomultiplier base to compensate cable attenuation, improve signal-to-noise ratio and reduce spill-over. First steps towards the design of PACIFIC++, the evolution of the SciFi readout ASIC for the

# 5

## L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

Mighty SciFi upgraded detector (Run 5) have been taken.



LHCb upgrade. Left: PicoCal PMT base. Right: PicoCal conditioning circuit board.

IFIC is also involved in the construction of the TWOCRIST proof-of-principle (PoP) of the double crystal-based g-2/EDM experiment at LHC. The PoP is scheduled for the 2025 run and will be installed at LHC IR3.

### Belle II upgrade

IFIC is the only Spanish institute participating in the Belle II experiment. During 2023, the collaboration has gone through a major detector update, completing the pixel vertex detector and other detector subsystems. IFIC is holding the role of chair of the technical board. As inner detector upgrade coordinators, IFIC is also leading the developments of depleted monolithic active

CMOS pixel sensors, in cooperation with several international partners (Belle II VTX Collaboration). The Conceptual Design Report has been completed during 2023.

### Future colliders

Detector R&D is focused on silicon sensors that are to be employed in the vertexing and tracking systems of a future electron-positron “Higgs factory” collider, and are also a key part of ultra-granular electromagnetic calorimeters. IFIC is part of AIDAInnova (integration, mechanics and cooling of silicon detector systems), of the CALICE collaboration (ultra-granular calorimeters) and of the ILD detector concept for the Higgs factory. More recently, IFIC joined the LUXE collaboration that will study QED in the strong-field limit by colliding the beam of the European XFEL and a high-power laser. Detector construction, with strong synergies with the Higgs factory R&D program is ongoing and first operation of the experiment is envisaged for the second half of the 2020s. IFIC furthermore makes an important contribution to the MAPP detector of the MoEDAL experiment.

The accelerator group develops compact accelerating structures and characterizes their performance in IFIC’s radio-frequency laboratory. Developments range from dielectric structures to Carbon nano-tubes. The group is also strongly involved in the simulation and modelling of breakdowns and beam dynamics, and in the development of instrumentation for beam lines. The expertise in electromagnetic effects and

radio-frequency cavities furthermore forms the basis for IFIC’s contribution to axion searches in the RADES and CADEX experiments. A major impulse to accelerator R&D has come from the approval of a new facility at IFIC to study ion therapy. This project includes the development of a linear accelerator-injector for Carbon ions (C6+) with an energy of at least 10 MeV/nucleon, as the first stage of a complete Carbon ion installation. This installation will operate at IFIC to advance pre-clinical bio-medicine and radio-biology.

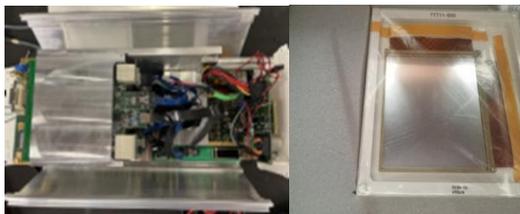
### AGATA

The group at IFIC has contributed to AGATA and the complementary instruments NEDA and GRIT. AGATA Phase 2, aiming to complete the array with a solid angle coverage of 3, started in late 2021. Our group, together with ETSE-UEG, is contributing to the development of the new electronics, with the coordination of the Front-End Electronics working group and the development of the pre-processing board. During 2023 the development was completed. The electronics water-cooling parts have been commissioned in 2023 and are being produced at IFIC. The group is also contributing to the performance evaluation and improvement of the array. Our group, together with ETSE-UEG, is as well contributing to the construction and electronic developments for GRIT, conceived for optimal study of reactions using low and intermediate energy radioactive ion beams. The device consists in a new type of compact, highly segmented Double Sided Silicon Strip

## 5

## L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

Detector (DSSSD) telescope array, optimized for integration in gamma detector arrays such as AGATA. During 2023 the group has contributed to the coordination of the GRIT collaboration, and we have started the procurement of detectors and the definition of our contribution to the electronics. Regarding NEDA construction, we have started the production of a new batch of 10 detection modules in 2023. This year the group has also started the design of a new layer of DSSSD to contribute to the instrumentation development of the HISPEC/DESPEC collaboration at FAIR, the so-called DINTESPEC demonstrator. In the future, we envisage the use of DINTESPEC with AGATA, the central  $\gamma$  spectrometer of the future in-beam experiments with intense RI beams.

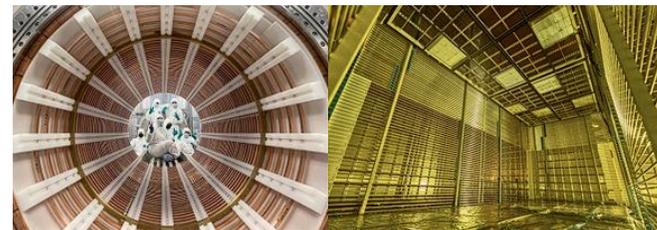


Left: full AGATA electronic channel. Right: one of the first squared 500  $\mu\text{m}$  thick, 1mm pitch, NTD E DSSSD detector produced as IFIC contribution to GRIT by MICRON semiconductor.

### DUNE/T2K/NEXT

IFIC completed the installation of the NEXT-100 detector at the Laboratorio Subterráneo de Canfranc (LSC) in 2023, leading the work on mechanics, gas system, slow controls, and the active veto against cosmic muons. NEXT-100 aims to conduct the first competitive search of the neutrinoless double beta decay with the NEXT technology (electroluminescent gas-pressure TPCs), as well as to set the grounds for a future ton-scale detector. The R&D lines towards the implementation of this massive device continued during 2023, involving the design of a barrel fiber detector and different TPC operation conditions taking advantage of the DEMO++ detector operated at IFIC.

IFIC is heavily involved in the R&D and construction of the DUNE far detectors and their prototypes at CERN, leading the cryogenics instrumentation (CI) and having a major role in the photon detection system (PDS). During 2023 the technical design report for the second far detector module was completed, with coordination of both PDS and CI chapters from IFIC researchers. IFIC has also coordinated the installation of those systems in the CERN prototypes, which were completed in 2023, with data taking starting mid 2024. Production of CI systems for the first DUNE far detector has started at IFIC, while R&D on novel PDS and CI systems for phase-II far detector is progressing in the expanding DUNE-lab at IFIC.



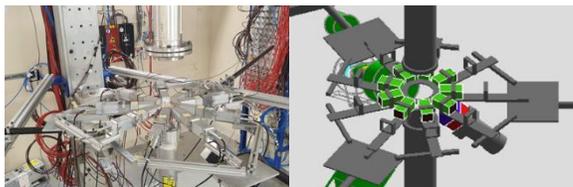
Left: the NEXT-100 TPC installed at the LSC, before closing the pressure vessel. Right: the ProtoDUNE-VD 4x6x6 m<sup>3</sup> Time Projection Chamber at CERN, with visible PDS modules (60x60 cm<sup>2</sup> at the top).

### n\_TOF + RIBs

In 2023, the CERN n\_TOF team at IFIC studied the potential use of active detectors for neutron-activation measurements at the new n\_TOF NEAR station, as well as the exploration of novel scintillation materials, such as deuterated stilbene for TOF capture experiments. The latter novel scintillation material is expected to open the possibility for next generation solid-state segmented total-energy detectors with enhanced detection sensitivity and selectivity. This endeavor marked the inaugural exploration at CERN of implementing a cyclic activation methodology (CYCLING). To achieve this goal, the team conducted comprehensive Monte Carlo simulations using FLUKA and Geant4, alongside in-situ measurements employing inorganic scintillators. These advancements are poised to create new avenues for directly measuring short-lived isotopes pivotal to the intermediate process of stellar nucleosynthesis.

# 5 L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

Regarding instrumentation for Radioactive Ion-Beam experiments, the first-time integration of the DTAS Total Absorption Gamma-ray Spectrometer within the DESPEC/NUSTAR collaboration setup (FRS in-flight ion separator and AIDA implantation-decay array) was successfully accomplished for the Phase-0 experiment S505 at GSI/FAIR (Germany).



Left: state-of-the-art segmented TED array at CERN n\_TOF EAR. Right: MC geometry for the next generation of TED-arrays based on deuterated stilbene.

## Computing

The research topics of the IFIC ATLAS-GRID Team include mainly the Spanish ATLAS Tier-2 goals. The exploitation of LHC data in Run 3 will push to the limit the computing resources available. This includes several generic activities devoted to the application of Distributed Computing and to improve the

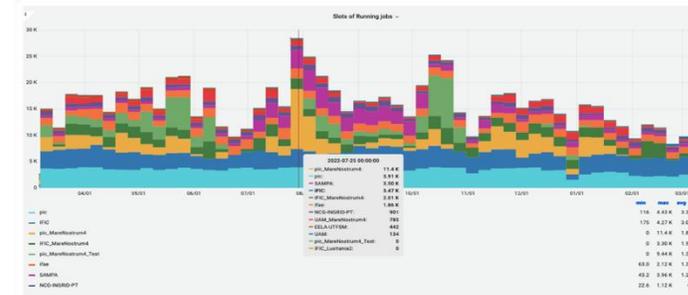
performance of the physics analysis work:  
a) Delivery of the committed resources for 2023. The Tier-2 IFIC site has provided 58600 HS06 and 4600 TB of disk. The efficiency of the whole Tier-2 has been about 100%.  
b) During 2023 our group has continued the exploitation of MareNostrum 4 HPC (BSC) running conventional ATLAS simulated data production. The computing yield has been more than 33 million CPU hours and more than 550 millions of events of a complete simulation of the detector. The 50% of the simulation production assigned to Spain is executed in MN4 resources.

c) The group has continued their duties with the ATLAS Event Index project (ATLAS event catalog).

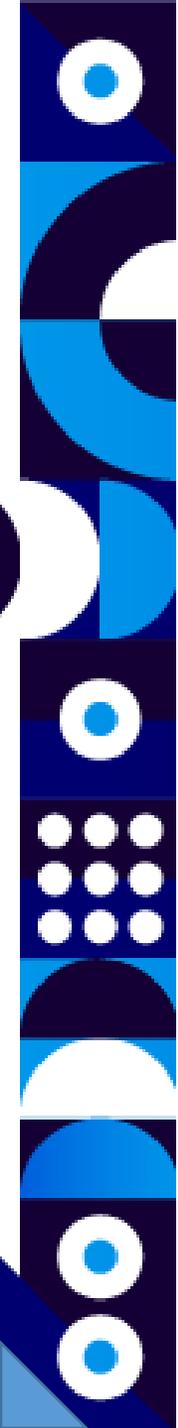
d) The group has taken the responsibility to coordinate the ATLAS Derivation System. This is the last step in the ATLAS Processing chain, reducing the size of the Analysis Object Data to a more manageable reduced format (Derivations).

e) In 2023, IFIC has been promoting the application of Machine Learning (ML) techniques for data challenges. These methods are being used in data fitting and event-reconstruction. The IFIC ATLAS-GRID team has performed studies of resonance decays into ttbar pairs using simulated data. Moreover, ML has been used by several Generative Models to produce simulated data at low computational cost. Most of this work was performed on the ARTEMISA infrastructure at IFIC.

f) In 2023, IFIC ATLAS team triggered a transversal effort to install an Analysis Facility to help physicists minimize time-to-insight, and enable iterative exploration of the data.  
g) The group has taken the responsibility to coordinate the ATLAS Distributed Analysis team.



More than 5k slots of running jobs during 2023, shown here by resource type, were the responsibility of IFIC. More than 10 million jobs (analysis+production) were completed.



# 5

## L7. ADVANCED INSTRUMENTATION AND COMPUTING IN FUNDAMENTAL PHYSICS

### Selected Publications

G. Aad et al. [ATLAS Collaboration], "New techniques for jet calibration with the ATLAS detector," Eur. Phys. J. C 83 (2023) no.8, 761. doi:10.1140/epjc/s10052-023-11837-9

Y. Unno et al., "Specifications and pre-production of n+-in-p large-format strip sensors fabricated in 6-inch silicon wafers, ATLAS18, for the Inner Tracker of the ATLAS Detector for High-Luminosity Large Hadron Collider," JINST 18 (2023) no.03, T03008. doi:10.1088/1748-0221/18/03/T03008

J. Collado, S. Capra, A. Pullia, N. Karkour, C. Houarner, V. Gonzalez, G. Wittwer, A. Boujrad, M. Kogimtzis and J. Lawson et al., "AGATA phase 2 advancements in front-end electronics," Eur. Phys. J. A 59 (2023) no.6, 133. doi:10.1140/epja/s10050-023-01045-0

C. Domingo-Pardo et al. [n\_TOF], "Advances and new ideas for neutron-capture astrophysics experiments at CERN n\_TOF," Eur. Phys. J. A 59 (2023) no.1, 8. doi:10.1140/epja/s10050-022-00876-7

G. Aad et al. [ATLAS Collaboration], "Search for light long-lived neutral particles that decay to collimated pairs of leptons or light hadrons in pp collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector," JHEP 06 (2023), 153. doi:10.1007/JHEP06(2023)153

### Selected Conference Talks

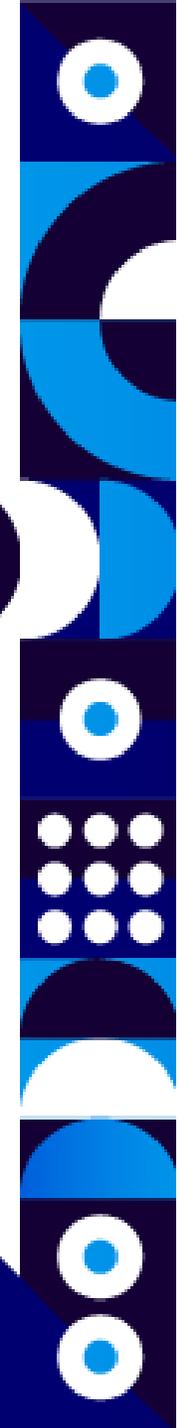
A. Irlles, "Detector challenges of the strong-field QED experiment LUXE", 57th Recontres de Moriond EW+U, March 18-25, La Thuile (France).

A.I. Morales. "Detectors for HISPEC-DESPEC", NuPECC LRP2024-TWG-Detectors and Exp. Tech. Kick-off Meeting, April 17-18, Frascati (Italy)

H. Amar, "The Photon Detection System of the DUNE experiment," L International Meeting on Fundamental Physics and XV CPAN days, October 2-6, Santander (Spain).

J. Lerendegui-Marco, "Recent highlights and prospects on  $(n,\gamma)$  measurements at the CERN n\_TOF facility", 17th International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics, July 17-21, Grenoble (France).

S. González de la Hoz, "Computing Activities at the Spanish Tier-1 and Tier-2s for the ATLAS experiment in the LHC Run3 period and towards High Luminosity (HL-LHC)", 25th International Conference on Computing in High Energy and Nuclear Physics (CHEP23), May 8-12, Norfolk (USA).



## ● SCIENTIFIC RESEARCH LINES

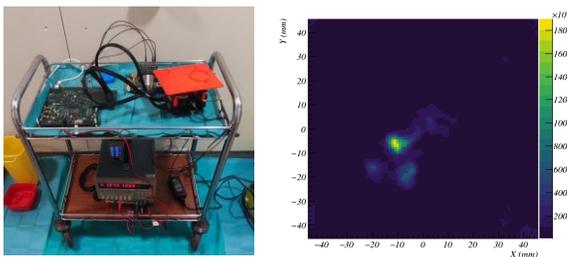


### **LINE 8. Advanced instrumentation and computing for societal challenges**

In recent years, the multidisciplinary and the societal impact of IFIC research projects has increased significantly. IFIC is developing various applications in medical therapy, imaging, dosimetry and diagnosis. Several gamma and neutron detectors are being developed with imaging capabilities. Neutron detectors to monitor neutron doses in therapy are being implemented. There is also a research line in diagnosis with a xenon-based PET-technology development, as well as a gamma-ray with ultrasound imaging device to guide breast biopsies in real time. Artificial Intelligence (AI) solutions are applied to medical diagnosis, including COVID-19, catastrophic event prevention, environmental studies, and space weather. Neutron detectors are developed for space weather and single event failures investigation. Detectors are developed for safety protocols in nuclear industry. IFIC researchers are developing a compact accelerator using carbon ions for hadron therapy. In quantum technologies, IFIC researchers harbour key expertise in quantum algorithms and quantum metrology.

# 5 L8: ADVANCED INSTRUMENTATION AND COMPUTING FOR SOCIETAL CHALLENGES

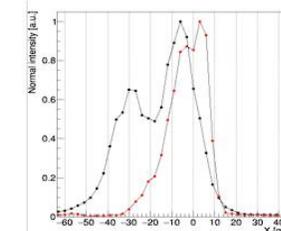
The IRIS group, devoted to medical physics, develops imaging systems for several applications including positron emission tomography (PET), hadron therapy treatment monitoring and radionuclide imaging in nuclear medicine. In the last case, an imaging system developed by the group is being assessed for verification and dosimetry of treatments with radiopharmaceuticals, in collaboration with the hospitals La Fe (Valencia) and Léon Bérard (Lyon). In 2023 it has been possible to image an alpha-emitting radionuclide (Ac-225) which was not possible for gamma cameras. In addition, a larger imaging system has been developed to enhance the efficiency. The activities, initially funded by the Proof-of-Concept project VALMONT, have been extended through the ASFAE project ICOR.



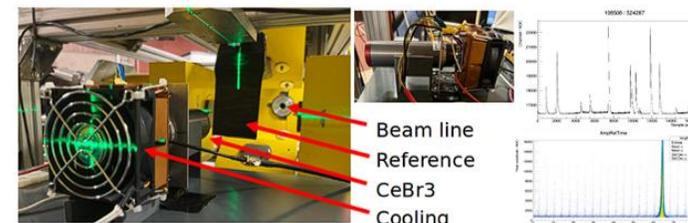
An imaging system developed by the IRIS group (left) has been able to image Ac-225 (right), an alpha emitter, at the hospital Léon Bérard in Lyon, which was not possible with gamma cameras.

Regarding hadron therapy monitoring, the system MACACOp has been tested in the Quirónsalud protontherapy centre, with a modern synchrocyclotron, which imposes higher technological challenges than older accelerators. The system has been able to image the distribution of prompt gammas emitted by a RW3 phantom upon irradiation with a high current proton beam delivered by this accelerator. In addition, a coaxial prompt gamma-ray detector is also being developed for the same application. The main activities involve Monte Carlo simulations of the electron amplification cascade as well as space charge effects within photomultiplier tubes, and experimental validation with radioactive sources, for optimizing its application in high count rate scenarios as that of prompt gamma-ray imaging in proton therapy. Fast Monte Carlo simulations in a GPU for proton therapy applications using open-source MOQUI, show great speed improvement over TOPAS. Also, a beam test at the ELBE bremsstrahlung accelerator at HZDR, Dresden, for testing the developed coaxial CeBr3 detector and the dead-time free data acquisition system has reached event count rates over 2 Mcps.

As a follow-up initiative stemming from the ERC Consolidator Grant HYMNS, the Gamma and Neutron Spectroscopy group was awarded two additional ERC Proof-of-Concept grants: Advanced imaging system for Medical Applications (AMA) and Gamma-Neutron Vision (GNVISION). AMA, aims to investigate the use of the hybrid Compton-PET technique



Imaging systems developed by the IRIS group have been tested at the protontherapy centre Quirónsalud (left) and the distribution of emitted photons, correlated with the Bragg peak, has been reconstructed (right).



Tests of the coaxial prompt gamma monitoring detector at HZDR (Dresden)

for dose monitoring in neutron-capture therapy and intraoperative radio-guided surgery. First successful proof-of-concept experiments were accomplished by the IFIC team at the ILL research reactor in Grenoble in 2023. The GNVISION project will concentrate on leveraging multimessenger (neutron-gamma) data to optimize proton-therapy treatments. A full conceptual study and

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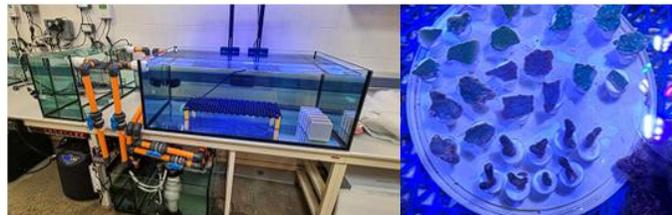
## L8: ADVANCED INSTRUMENTATION AND COMPUTING FOR SOCIETAL CHALLENGES

technical laboratory developments for GNVISION were achieved in 2023 by our team.

The patented technology of the MAGAS project that allows the guidance of cancer biopsy by combining molecular imaging with ultrasound and that allows improvement in the diagnosis and treatment of cancer has led to the creation of HYBRID IMAGING SYSTEMS S.L., a Company Based on Knowledge (spin-off) of the CSIC and the University of Valencia.

Besides medical physics, in 2023 the group had great advances in two other application projects. The REMO project, funded by Generalitat Valenciana under grant GVA-THINKINAZUL/2021/036, aims at the study of marine ecosystems using radiotracers (Ca-45) and advanced nuclear instrumentation. In 2023, two prototype detectors have been designed and the mesocosm mesocosm setup has been mounted. The HENSA++ project, funded by GVA under grant IDIFEDER/2021/002, is a novel detection system that provides spectral sensitivity across a wide neutron energy range, from meV to GeV. It will be deployed in a temporary facility at 2000 m above sea level for studying space weather and environmental dosimetry. During 2023, the final assembly and commissioning of electronics and auxiliary

systems has been carried out.



Prototype detectors and mesocosm setup of the REMO project

The PROMESA project (CIPROM/2021/64), has achieved relevant results in 2023 including the evaluation and risk reduction in brachytherapy with multiple simulations and collaboration with Hospital La Fe (with publication of results and key review), the development of a system for postal dosimetric audits (with publication of initial results) and the determination of toxicity in the skin of patients with breast cancer treated with radiotherapy through analysis of thermography and laser Doppler images in 327 patients.

During 2023, the accelerator group has continued, in collaboration with CIEMAT, with the physical design of a carbon ion injector, suitable for ions/protons. The first structure of the accelerator (a RFQ) has been manufactured and assembled and is going to be tested at CERN in 2024. In parallel, IFIC's accelerators group has been working on the control and acquisition system, based on  $\mu$ TCA technology and the design and implementation of Low Level RF components for the ion accelerator. This system will be integrated with the CIEMATs structure and

also tested at CERN. In a long term, this equipment will serve as the foundation for an installation that will operate at IFIC for its scientific exploitation in preclinical biomedicine and radiobiology.

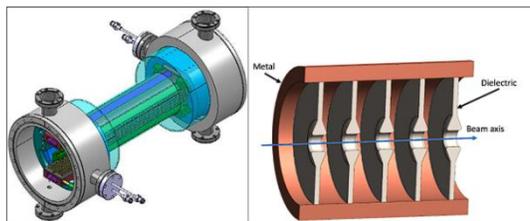
The group is also involved in the development, together with the company AVS (Added Value Solutions), of a high repetition rate, ultra-short pulse chopper for one of the experimental extraction lines of IFMIF-DONES.

On the R&D activities in 2023, the operation of the high-gradient test benches has been resumed to continue the studies on the KT structure. In collaboration with CERN, to achieve higher power efficiency, a novel accelerator structure based on ultra-low-loss dielectrics (DAA – Dielectric Assist Accelerating) has been designed and it is ready to be built. In this process, a new non-resonant ultra-fast multipactor regime in DAA structures was discovered, modelled, and published. The R&D on novel accelerating technologies continues, progressing on the development of the theoretical model for beam-driven wakefield acceleration in carbon nanotubes (CNT).

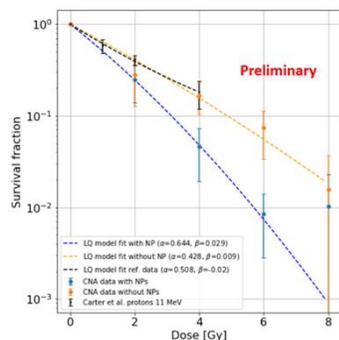
In the study of accelerator applications, two irradiation test campaigns have been conducted at CNA (Seville) to investigate the radiosensitization effect of gold nanoparticles in proton therapy treatment, proving a significant reduction in the survival fraction of the irradiated cells.

# 5

## L8: ADVANCED INSTRUMENTATION AND COMPUTING FOR SOCIETAL CHALLENGES



Left: Beam Extraction Device: 3D Design Overview carried out by AVS. Right: DAA structure prototype.



\*\*Compared with data from Carter et al. Complex DNA Damage Induced by High Linear Energy Alpha-Particles and Protons Trigger a Specific Cellular DNA damage. HeLa cells, 11 MeV protons at 5Gy/min.

Survival fraction of cells, loaded with gold NPs (blue) and not loaded (yellow), irradiated with protons.

The PETALO group is developing a prototype of a Positron Emission Tomography scanner based on liquid xenon, read out by silicon photomultipliers, with the aim of assessing the energy and time resolution attainable with this technology. In 2023, the group refined the measurement of the energy resolution of 511-keV gammas in liquid xenon, using scintillation light only and started studying the time resolution (Time-of-Flight) of the system, two key parameters for a future PET scanner based on liquid xenon.

The Space Weather project develops a real-time early warning system to evaluate the impact of hazardous geomagnetically induced currents produced by violent solar storms on Spanish critical infrastructures. A predictive model based on an LSTM network is developed to forecast the behaviour and severity of geomagnetic storms through various hour(s) ahead using interplanetary magnetic field data. Furthermore, the uncertainty of this prediction is also estimated, providing essential information to set reliable alarm thresholds, make informed decisions and take appropriate risk strategies.

### Selected Publications

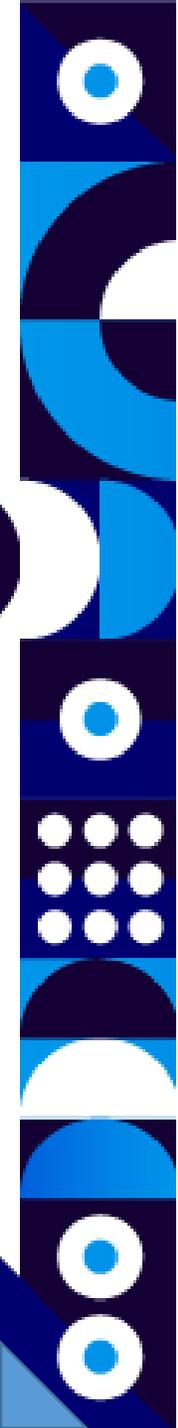
Influence of the background in Compton camera images for proton therapy treatment monitoring. M. Borja-Lloret, L. Barrientos, J. Bernabéu, C. Lacasta, E. Muñoz, A. Ros, J. Roser, R. Viegas and G. Llosá. Phys. Med. Biol. 68 (2023) 144001.

Hybrid PET/Compton-camera imaging: an imager for the next generation. Gabriela Llosá, Magdalena Rafecas.

Characterization of a Compton camera based on the TOFPET2 ASIC. R.Viegas, J.Roser, L.Barrientos, M.Borja-Lloret, J.V.Casaña, J. García López, M.C. Jiménez-Ramos, F.Hueso-González, A.Ros, G.Llosá. Radiation Physics and Chemistry 202 (2023) 110507.

L. Beaulieu, F. Ballester, et al., "AAPM WGDCAB Report 372: A joint AAPM, ESTRO, ABG, and ABS report on commissioning of model-based dose calculation algorithms in brachytherapy", Med. Phys. 50, e946 (2023).

P. Martín-Luna et al. On the Magnetic Field of a Finite Solenoid, IEEE Transactions on Magnetics ( Volume: 59, Issue: 4, April 2023).



# 5

## L8: ADVANCED INSTRUMENTATION AND COMPUTING FOR SOCIETAL CHALLENGES

D. Conde, F. L. Castillo, C. Escobar, C. García, J. E. García, V. Sanz et al. (2023). Forecasting geomagnetic storm disturbances and their uncertainties using deep learning. Space Weather, 21, e2023SW003474.

### Selected Conference Talks

G. Llosá. Individualized treatment verification based on photon emission. Invited Talk at 4th International Conference on Dosimetry and its Applications. Valencia, 16-20 Oct. 2023

G. Llosá. Advances in medical physics from Nuclear and HEP. Invited Talk at L IMFP23 and XV CPAN Days. Santander, 2-6 Oct.

R. Viegas, J. Roser, L. Barrientos, M. Borja-Lloret, J.V. Casaña, F. Hueso-González, J. Pérez-Curbelo, A. Ros, and G. Llosá. Compton camera performance as treatment monitoring system at a Proton therapy center. Talk at PTCOG 61. Madrid, 10-16 June 2023.

P. Martinez-Reviriego et al. Dielectric Assist Accelerating structures for compact linear accelerators of low energy particles in hadrontherapy treatments, JACoW IPAC2023 (2023) WEPA122.

N. Fuster-Martinez et al. Preliminary studies of the radiosensitization effect of gold NPs for hadrontherapy. IV Jornadas RSEF/IFIMED de Física Médica.

P. Ferrario on behalf of the PETALO Collaboration, Status and perspectives of the PETALO project, XeSAT 2023, June 2023, Nantes, France.

# 6

## TECHNOLOGY TRANSFER



## 6 TECHNOLOGY TRANSFER

FIC has a serious commitment to promote the societal impact of our research. The Innovation and Technology Transfer Office (UCIE) at IFIC ([Unidad Científica de Innovación Empresarial - UCIE](#)) serves as a connection between the researchers and the needs of technology institutes and industry. UCIE has established its role inside the institute as go to office for researchers seeking guidance to port their developments to outside academia.

UCIE is funded by the Valencian Agency for Innovation (AVI). This year AVI changed its funding strategy implementing a competitive call for proposals. IFIC-UCIE's proposal was considered among the best ones.

### **Innovation Agents**

César Blanch      Rosa Rodríguez  
Ana I. Delgado      César Senra

Contact: [ucie@ific.uv.es](mailto:ucie@ific.uv.es)

## 6 TECHNOLOGY TRANSFER

UCIE has firmly established itself within the institute as the primary resource for researchers looking to transfer their developments beyond academia. The support to the UCIE from Generalitat Valenciana through Valencian Agency for Innovation (AVI) continued during 2023. The project has been extended to 3 years, providing some more stability to the plans and actions developed at UCIE.

Many advances have taken place during the year related to intellectual property and innovation:

- An important milestone has been achieved for IFIC with the creation of an Innovative and Technology-Based Company (EBT) as a result of a licensed patent from the institute. The last success of this kind occurred nearly 20 years ago.
- One of IFIC's inventions has received funding through a "Proof of Concept" grant from the European Union (ERC program) for its development.
- One of the projects was awarded an honorable mention in the Most Impactful Project category at the SECOT awards.
- An industrial PhD program has been initiated, thanks to the collaboration and patents between the company and IFIC.

A point that will become increasingly significant in the coming years is related to studies on hadron therapy and compact linear accelerators. IFIC is one of the driving forces behind the Pre-Commercial Procurement (PCP) by the CDTI for the development of a compact linear accelerator for use in hadron therapy. The resulting pre-operational prototype will be handed over to IFIC, which will provide the real-world environment necessary to validate the technology. This will greatly boost IFIC's hadron therapy projects, which are already supported by UCIE.

### Actions aimed at reinforcing internally and externally the impact of the IFIC UCIE

Successful actions have been continued and more have been added to strengthen innovation and technology transfer ecosystem at IFIC and its relations with outside partners. Among those some relevant or new during 2023:

Communication actions:

- UCIE-IFIC website, with continuous updates on news, the inclusion of new capabilities, and videos showcasing IFIC's technologies and their applications.
- Continuation of the already consolidated monthly newsletter including news during that month published at IFICs web and information about Innovation and Technology Transfer.

The training program for the institute's researchers continues.

Through the UCIE, IFIC has been present at local, national and international technological

forums and meetings:

- [Transfiere](#): Transfer Forum 2023 in Malaga.
- Organization of JORNADA IFIC-EMPRESA an event to put together innovative companies with challenges related to the IFIC capabilities companies with research groups and pre/post-doctoral researchers, together with Oficina de Jóvenes Investigadores (OJI).
- REDIT SUMMIT, an initiative to promote collaboration between research centers, companies and institutions through knowledge.
- Overall UCIE has participated and represented IFIC in no less than 50 events (courses, conferences, seminars, webinars...).

IFICs UCIE has continued working in close collaborations with national and regional alliances as:

- InnDIH, Digital Innovation Hub for the economic boost of the Valencian Community which includes Universities, Research and Technological centers from the Valencia Community.
- INEUSTAR and INDUCIENCIA, Spanish association to promote the Science Industry sector, and in the search for transversality towards other sectors.

### Organization of training related to Innovation and technology transfer

Among other initiatives, during 2023, UCIE got the support of OEPM (the Spanish Patent and

## 6 TECHNOLOGY TRANSFER

Trademark Office) during a dedicated session about scientific results protection. The main goal was to provide guidance on the best technology transfer path.

### Specific actions to support groups with technological potential and impact

During 2023, UCIE has consolidated the number of projects which are being closely watched and possess potential for a transfer to industry. The list of projects that have been checked and/or helped by UCIE:

**HGRF:** study and characterization of radiofrequency cavities. Conducts research on high gradient phenomena and develops RF technology, paying special attention to systems for medical and industrial applications.

**RADON:** environmental radioactivity measurement and radiological monitoring. Promotes measurement of radon in air for the prevention of lung cancer.

**RX3D:** It looks for applications in areas of health for RX3D and improve the experience in its use.

**UCNAOH:** Maximizes the benefits of cancer

therapies based on the use of protons and ions, i.e., hadrontherapy.

**GNVISION:** Implements dual neutron and gamma radiation imaging device, capable of displaying both gamma radiation and neutron emitters.

**RADIOIMAGEN:** Development of a system to improve imaging capabilities in treatments and diagnosis with radiopharmaceuticals.

**KAIROS:** Wireless sub-nanosecond data reading and synchronization system for multisensor detectors.

**TRITIUM:** Real-time monitoring of tritium activity in water.

**ARTEMISA:** Artemisa is IFIC's Big Data and Artificial Intelligence (AI) infrastructure for research and experimentation.

**ASICOLD:** Guided biopsy in breast cancer using a hybrid gamma imaging and ultrasound system.

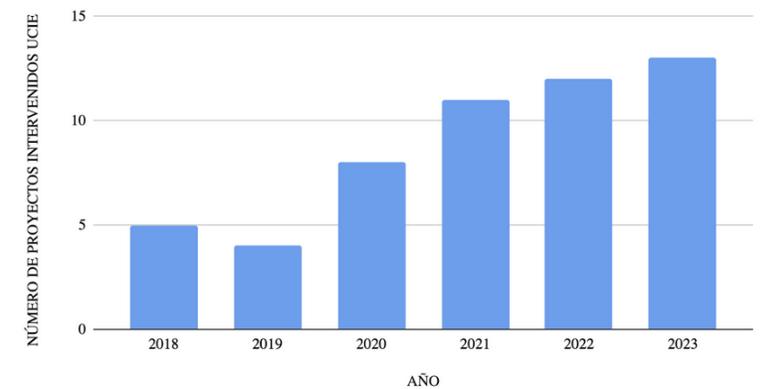
**PRIDE:** Proton Range and Imaging Device.

**REMO:** Radiotracers for the study of marine and ocean ecosystems.

**PRAGMA:** Proton range verification by gamma ray monitoring.

Additionally, important work was carried out to identify calls and other opportunities for collaborative projects in relation to the challenges that IFIC technologies can solve.

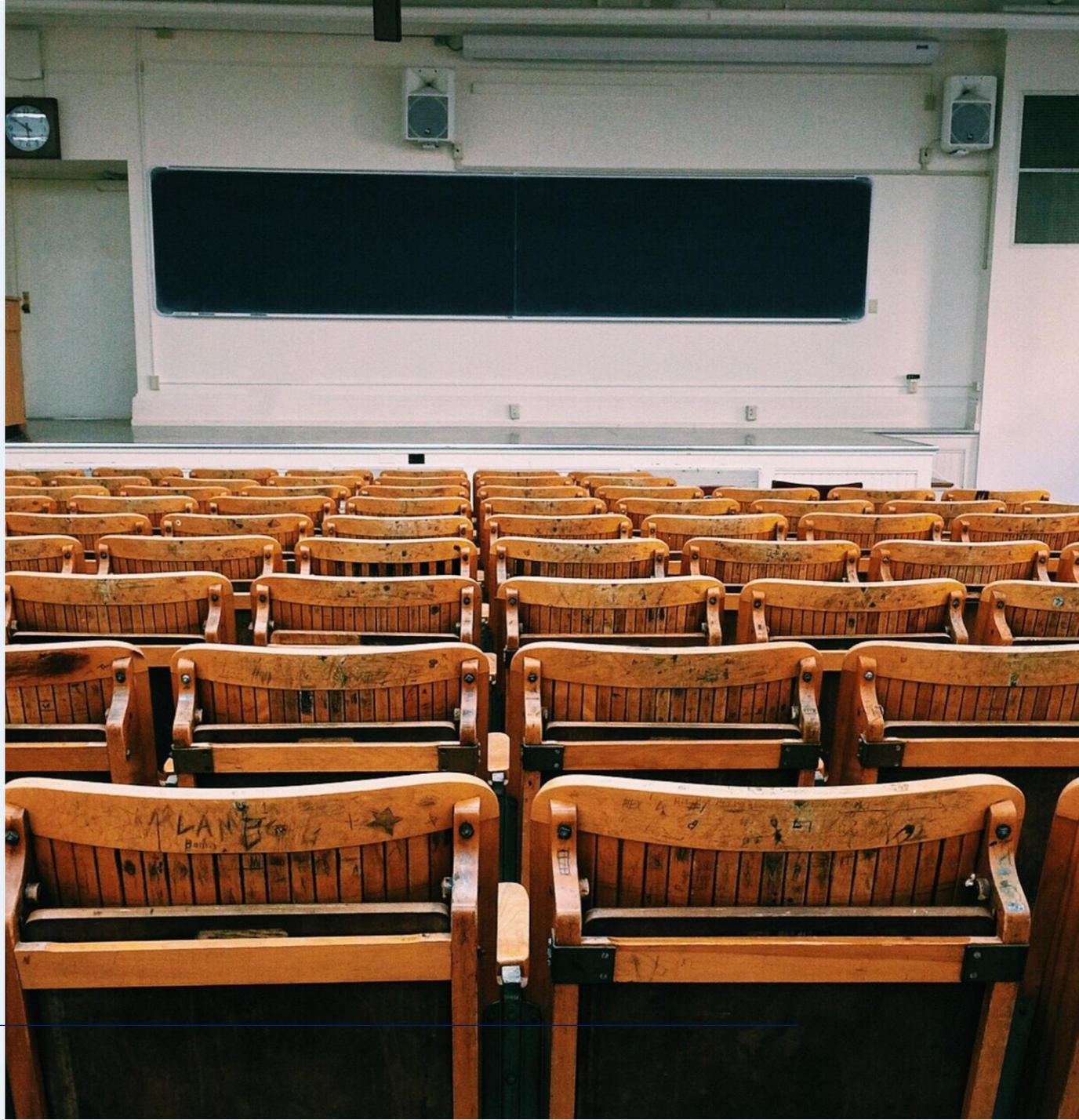
NÚMERO DE PROYECTOS AL AÑO CON INTERVENCIÓN DE LA UCIE-IFIC



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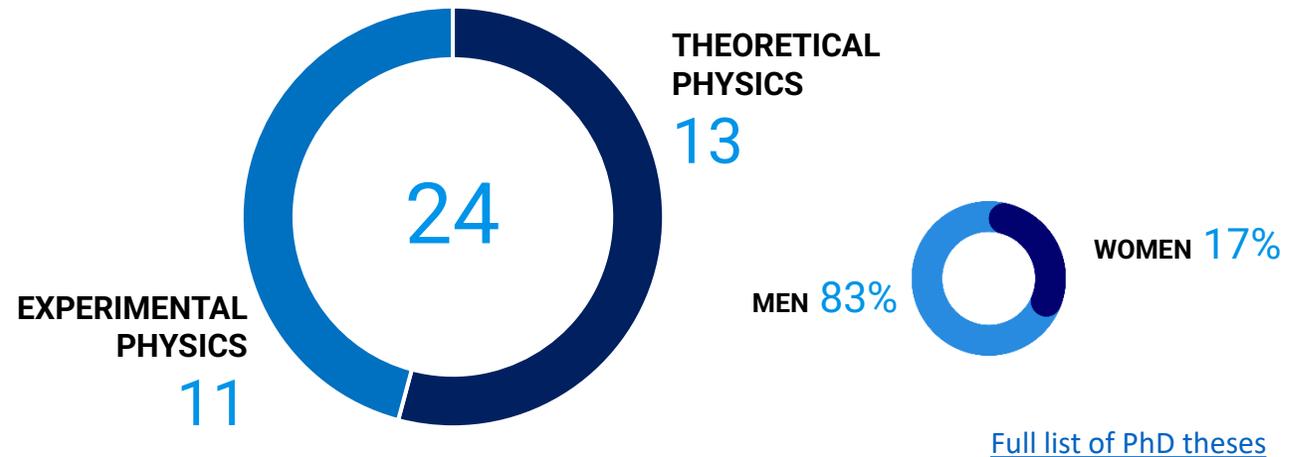
# TRAINING



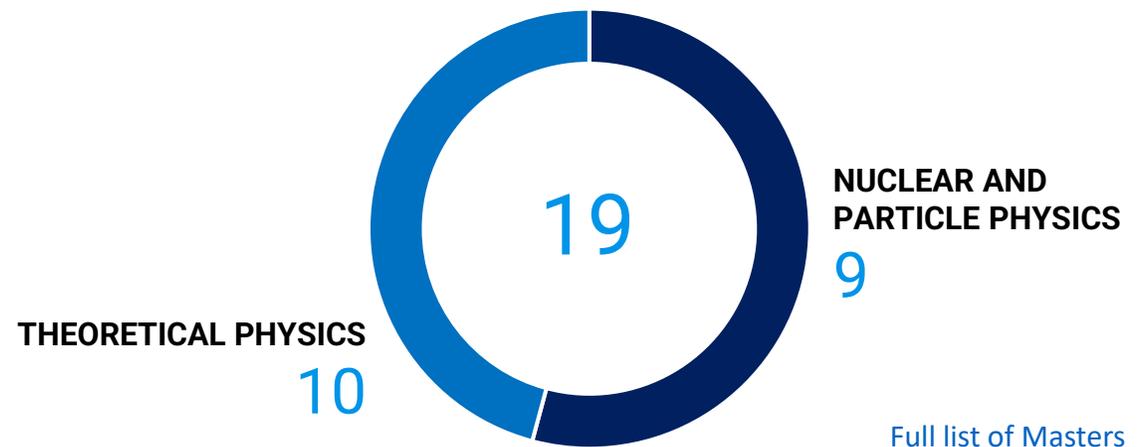
# 7 TRAINING

The members of IFIC with positions at the University of Valencia are mainly involved in its Degree in Physics, although they also teach in Chemistry and Engineering. At the postgraduate level, IFIC participates in two of the Master's Degrees offered by the UVEG: Master in Advanced Physics and Master in Medical Physics. In the former, we are responsible for two of the four specialities: Theoretical Physics and Nuclear & Particle Physics. IFIC also coordinates the PhD program in Physics at the UVEG.

## PHD THESES WITH IFIC SUPERVISORS



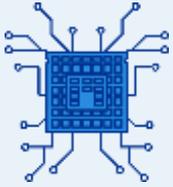
## MASTER PROJECTS



# COMMITTEES



8



# ARTIFICIAL INTELLIGENCE



# 8 ARTIFICIAL INTELLIGENCE

**A**rtemisa is a cutting-edge Big Data and Artificial Intelligence (AI) infrastructure designed for research and experimentation. Located at IFIC's data center, Artemisa is a GPU-intensive computing system, equipped with the latest generation GPUs, as well as ample CPU power and disk space. This facility offers a secure, reliable and high-performance environment that accelerates the development of AI and big data projects.

## Members

Artemisa: Jose Enrique García, Arantza Oyanguren, Alberto Ramos, Roberto Ruiz, Jose Salt, Bryan Zaldivar.

IT team: Matías Salinero, Javier Sánchez.

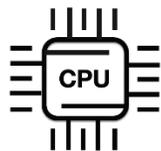
Director: Nuria Rius.

# 8 ARTIFICIAL INTELLIGENCE

## ARTEMISA

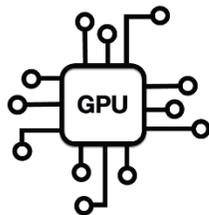
ARTificial Environment for ML and Innovation in Scientific Advanced Computing

Artemisa is currently composed of a total of 35 servers. 22 servers host one NVIDIA GPU Volta V100 each and 11 servers one NVIDIA GPU Ampere A100. Additionally, there are two multi-GPU servers, one with a 4-V100 NVIDIA GPU and one 8-A100 NVIDIA GPU. The servers are especially suitable for computing in artificial intelligence. In addition to these servers, which must be used in “batch” mode, there are two interfaces where the users can previously test their software.



3400 CPUs

160.000 Hours  
Delivered in 2023

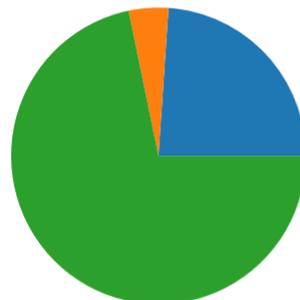


44 GPUs

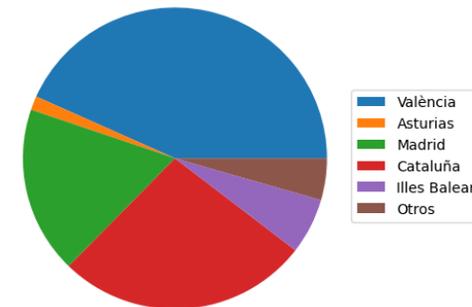
150.000 Hours  
Delivered in 2023

During 2023, Artemisa performed reliably and continuously, managing to deliver an infrastructure record of 150 thousand hours of GPU to the projects. Around 40 projects have requested computing resources at the facility at each of the three calls opened during 2023.

The Artemisa infrastructure has continued to provide service to several regions and areas, encouraging groups of different lines and origins (CV institutes and other communities) to participate in the calls and use the services it offers. Although a large part of the projects originate from IFIC, the majority comes from external institutions.



■ Astronomy, Space and Earth Sciences  
■ Life and Health Sciences  
■ Mathematics, Physics and Engineering



■ València  
■ Asturias  
■ Madrid  
■ Cataluña  
■ Illes Balears  
■ Otros

The pie charts in the figure show the distribution of the projects by region of origin and area of the projects. The distribution has remained almost stable for the last years. Communities such as Madrid and Catalonia continue to dominate the projects from outside Comunitat Valenciana.

The computing resources have been utilized by a wide variety of projects, all of which share a common reliance on Artificial Intelligence as a core analytical tool. While the majority of these projects are focused

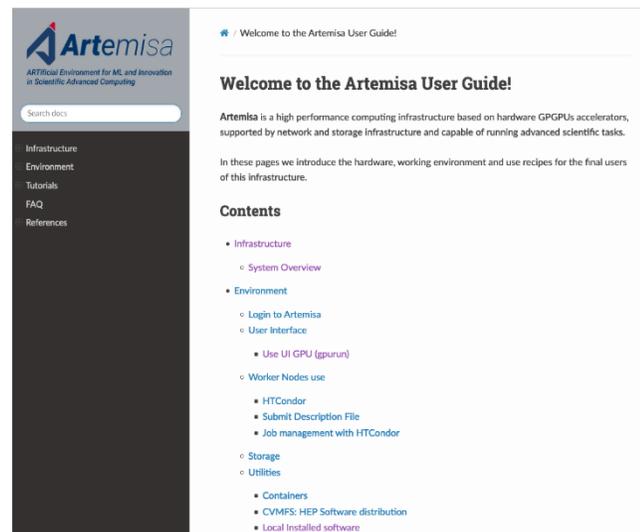
# 8 ARTIFICIAL INTELLIGENCE

on activities and research in fundamental physics, a significant portion is dedicated to other fields, including health and earth sciences.

Thanks to the funding obtained within the “Programa de I+D+i de Astrofísica y Física de Altas Energías”, a computing engineer was recruited to work on strengthen the infrastructure by: improvement of the software, documentation and support, and define/install a hardware upgrade of the infrastructure. The work done so far includes:

- Software, documentation, and support improvements: A new section with detailed documentation for new users has been enhanced and introduced on the infrastructure’s website. Additionally, the response time for user support has been improved.
- Hardware improvements: The hardware planned for acquisition in the next fiscal year has begun to be defined.

The Artemisa team remains actively involved in initiatives and projects aimed at promoting the



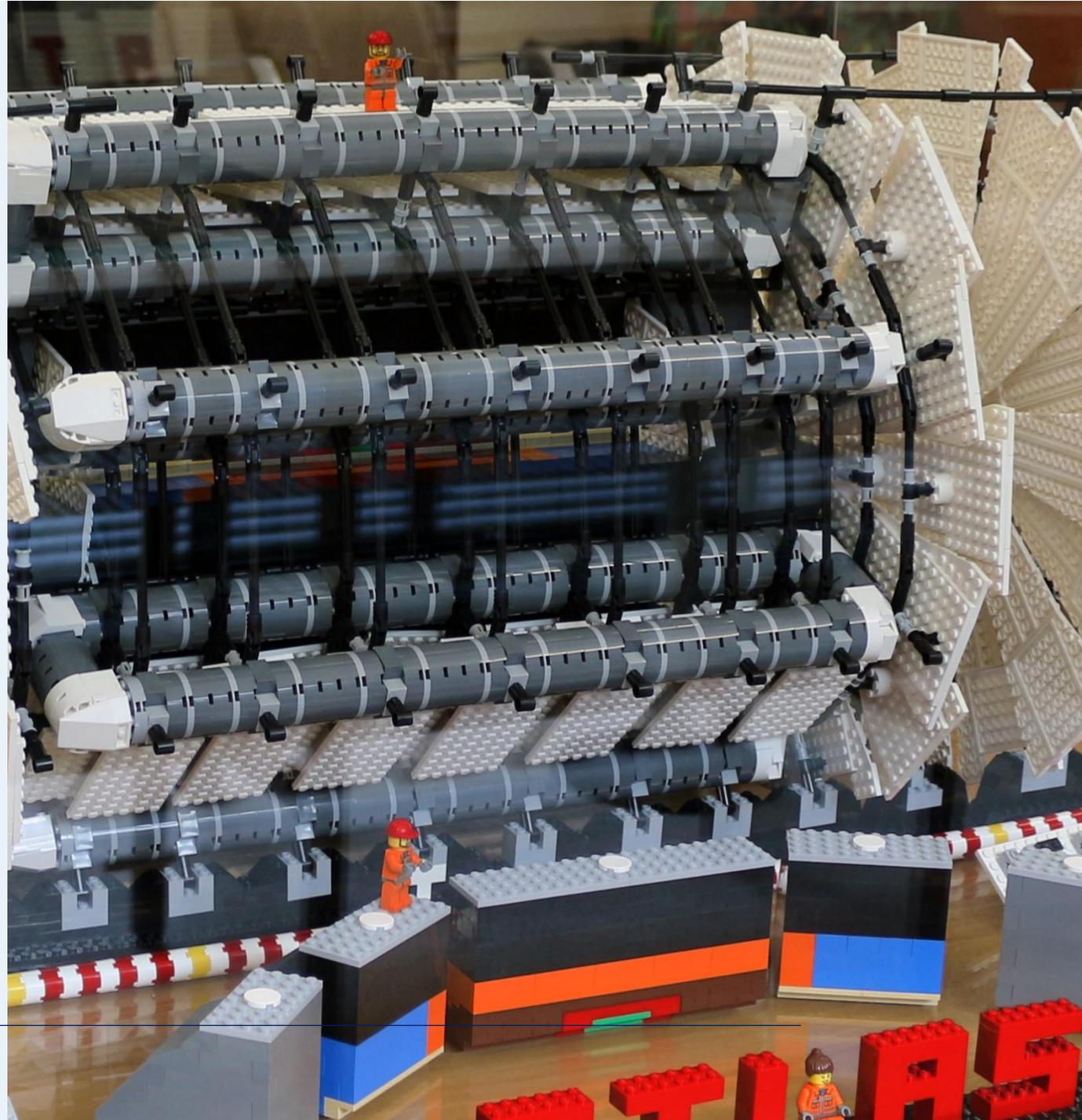
use of its computing resources. Artemisa is a participant in the InnDIH project (European Digital Innovation Hub of the Valencia Community), which was launched in January 2023 with funding from the European Commission. [InnDIH](#) is supported by the EU, along with national and regional governments, to aid in the digitization of SMEs and public administration, while fostering the economic growth of the Valencian Community. The first contract with an SME was signed last year.

Several activities related with Artemisa and AI have taken place during 2023 in the framework of the AIHUB, InnDIH and COMCHA network. There are several examples of these activities. For instance, workshops that took place in the AIHUB summer school, where the participants took part in a 3-day hackathon to gain knowledge in AI and ML tasks using Artemisa. As well, the third school on Computing Challenges (COMCHA) for the HL-LHC era was held in 2023, where almost 30 participants had the opportunity to perform several ML tasks in a high performance computing infrastructure, experiencing the gain in throughput compared to regular computers.

9



# OUTREACH



# 9 OUTREACH COMMITTEE

IFIC actively sponsors and participates in a good number of outreach activities, made possible through the active engagement of our Institute's members. These activities encompass a wide range, from public talks held outside our facilities to opening our laboratories' doors, targeting both the general public and the educational community.

In 2023, eight individuals from IFIC led the Outreach Committee, overseeing these activities. Ángela Molina managed our website, social media presence, and liaised with journalists and press offices from other institutions. Alberto Aparici coordinated activities and materials aimed at students and the general public. Núria Falcó managed the scientific communication and outreach of the strategic network CPAN, which is managed from IFIC, and provided support to IFIC's communication and outreach. Additionally, five IFIC staff scientists played crucial roles in coordinating and developing these activities: Enrique Nácher, Olga Mena, Avelino Vicente, Emma Torró and Carlos Escobar.

The committee's efforts are complemented by the active involvement of numerous IFIC researchers and technical staff engaged in outreach activities and logistics.

It's worth noting the significant impact achieved through the Meitner Project and the Oscilador Armónico Podcast, which were funded by FECyT, among other institutions.

## Outreach Committee

Ángela Molina	Olga Mena
Alberto Aparici	Enrique Nácher
Núria Falcó	Avelino Vicente
	Carlos Escobar
	Emma Torró



# 9 OUTREACH CONTRIBUTIONS

## 22 Guided tours for students

Visits recovered some measure of normalcy during the 2022/2023 academic year, and as a result the institute received over 500 visitors from 22 different high schools. Thirty members of IFIC and twelve laboratories were involved in the visits.



## 50 High school talks

IFIC researchers offer their services to local high schools to give talks on various topics related to our research. In 2023, these talks reached more than 2,300 students and covered six areas of knowledge, incorporating two new topics: quantum physics and artificial intelligence.



# 9 OUTREACH CONTRIBUTIONS

## 1 Training course for secondary school teachers

This course aims to provide high school teachers with some background in topics related to IFIC research, such as accelerator physics, cosmology, and nuclear physics. In 2023, the course was held online with a couple of optional in-person sessions, and 75 teachers attended.

### Curso de formación IFIC-CEFIRE: Física de partículas, física nuclear y cosmología para profesores de secundaria

28 ene. 2021 17:30 → 29 mar. 2021 19:30 Europe/Madrid

Online

**Descripción** Este curso pretende hacer llegar a los docentes de secundaria algunos conceptos básicos relacionados con la física de partículas, la física nuclear y la cosmología. Se repasarán algunos aspectos de la teoría de la relatividad, la teoría cuántica, el Modelo Estándar y la gravedad de Einstein, y se destacarán algunas de sus aplicaciones, como el diagnóstico médico utilizando técnicas nucleares. También se incluirá material sobre experimentos caseros que se pueden realizar en las aulas relacionados con la física de partículas. Algunos de los ponentes serán científicos expertos en áreas específicas, lo que permitirá también exponer en qué dirección se orienta la investigación en la actualidad.

El curso está organizado por el Instituto de Física Corpuscular (IFIC) y el CEFIRE específico para Ciencia, Tecnología, Ingeniería y Matemáticas.

Inscripción

Contacto [alberto.aparici@ific.uv.es](mailto:alberto.aparici@ific.uv.es)

JUEVES, 28 ENERO

17:30 → 19:30 **Introducción a la teoría de la relatividad**

2h

El movimiento de la luz. La percepción del espacio y tiempo es diferente para observadores diferentes. La velocidad de la luz como límite. La fuerza de la gravedad como fuerza de inercia: principio de equivalencia y espacio-tiempo curvado. Agujeros negros. Ondas gravitacionales.

Ponente: Alberto Aparici (IFIC)

## 4 Physics Masterclasses

IFIC once again organised four masterclasses for high school students: three centered on the experiments ATLAS, LHCb, and MINERvA, and commemorating the International Day of Women and Girls in Science. Three hundred students from 90 centers across the Valencian Community attended.



# 9 OUTREACH EVENTS

## 1 Armonía Cuántica

*Armonía Cuántica* is a project that aims to bring together IFIC researchers with students of the Valencia Conservatory to create an environment where science can inspire the arts. The theme for 2023 was the Higgs boson, and the result was four pieces that translated these particle physics concepts into music.



## 2 Dark Matter Day

IFIC organized two conferences in celebration of Dark Matter Day: one at the Museum of Sciences in Valencia and another at the Planetarium of Castellón. Both conferences had an attendance of about 75 people.

CIUTAT DE LES ARTS I LES CIÈNCIES **ACTUALIDAD**



Conferencia  
Buscando la materia oscura en nuestro cosmos  
Lunes, 30 de octubre de 2023 – 19.00

**Olga Mena Requejo**  
Investigadora Científica.  
Instituto de Física Corpuscular (CSIC-UV)

Auditori Santiago Grisolia. Museu de les Ciències

GENERALITAT VALENCIANA | CIUTAT DE LES ARTS I LES CIÈNCIES | IFIC

**DIA DE LA  
MATÈRIA FOSCA**

DIVENDRES 27 D'OCTUBRE 2023 A LES 18.00 H

18.15 H – CONFERENCIA  
**ALBERTO APARICI**

19.00 H – PROJECCIÓ FOLLDOME  
PHANTOM OF THE UNIVERSE

ENTRADA GRATUITA FINS A COMPLETAR AFORAMENT

Dark Matter Day | Castellón | Planetari de Castellón | IFIC

# 9 OUTREACH EVENTS

## Expociència XV

Expociencia, the open door day of Parc Científic, reached its 15th edition with a complete return to normalcy. More than 3,500 people attended, and IFIC offered 11 activities, with over 50 researchers involved.



## Experimenta XVIII

Experimenta is a festival organised by the Faculty of Physics in Valencia and aimed at high school students, who submit their science projects for a contest with several categories in physics and technology. IFIC collaborates regularly with the festival.



# 9 OUTREACH IFIC IN MEDIA

## 25 IFIC in the news

Several initiatives and research results involving IFIC reached the news in 2023, and in all cases statements from members of the institute were provided for the journalists.



## 100 Radio and podcast pieces

Several members of IFIC collaborate regularly with radio shows and podcasts that have science as their primary theme. In 2023 IFIC began producing its very own podcast, on which we comment in the following pages.



# 9 OUTREACH - GENDER PROJECT

## Podcast Oscilador Armónico

Oscilador Armónico is a podcast entirely produced at IFIC, aimed at bringing a wide variety of physics-related topics to the general public. Each episode explores a specific topic in depth, usually through an interview with an expert, and also features several short segments covering other matters, always with physics as the connective tissue.

Led by IFIC researcher Enrique Nácher and directed by science communicator Antonio Rivera, Oscilador Armónico has made a strong entry into the Spanish-speaking podcast scene, reaching over 7,000 downloads per episode in its debut year.

The podcast features several collaborators, mostly researchers from IFIC: Avelino Vicente, Valentina de Romeri, Isabel Cordero, Alberto Aparici, Pablo Martínez, Belén Samper, Gonzalo Sánchez, and José Antonio Victoria.



# 9 OUTREACH - GENDER PROJECT

## Proyecto Meitner

It is a project promoted by the Institute of Corpuscular Physics (IFIC) with the collaboration of the Spanish Foundation for Science and Technology (FECYT) - Ministry of Science and Innovation. With it, the IFIC recovers and revalues the contribution of the great pioneers of Nuclear and Particle Physics through the figure of Lise Meitner.

A play, a conference on science and gender, a science and art contest, videos on social networks and a lot of educational material to give visibility to women in science, bringing scientists of the past and present in Nuclear and Particle Physics to all audiences. And all with the aim of promoting social equality and scientific culture, encouraging scientific vocations and highlighting the legal, cultural, historical and social barriers that women scientists have faced throughout history.

In this project, the participation of both the dissemination and the equality and diversity committees has been fundamental.



# 9 OUTREACH-GENDER PROJECT: PROYECTO MEITNER

## Theatre: Proyecto Meitner



This is the story that brought the Meitner Project to life, based on the work of Robert Friedman: Remembering Miss Meitner. Friedman is a professor of History of Science at the University of Oslo and a playwright. More than 4800 people have watched the play.

## Conferences



The gender and science conferences were aimed at the general public and secondary school teachers and training cycles through through CEFIRE, more than 120 registrations were made.

## Art Contest: Express-Arte ConCiencia



The contest was aimed at secondary school and vocational training students. A total of 52 assignments were accepted in the competition. 40 people attended the Awards ceremony and 20 followed the ceremony remotely.

# 9 OUTREACH-GENDER PROJECT: PROYECTO MEITNER

Exhibition: 'PIONERAS'



The PIONERAS exhibition has been created, divided into two parts: one that includes the winning pieces of the art contest and another that includes images of pioneering women in nuclear physics, created by an artist.

Artistic workshops



The group organized artistic expression workshops to facilitate students' participation in the art contest.

Mentoring program: #magnIFICa



Female Physics students were able to learn what it is like to be a scientist at IFIC

# 10

## EQUALITY AND DIVERSITY COMMISSION



# 10 EQUALITY AND DIVERSITY COMMISSION - CID

## CID commission

### Coordinators:

Emma Torró Pastor  
Neus López March

### Members:

María Teresa Andreu García  
Andrea Donini  
Marta Lanzac Berrocal  
Raquel Molina Peralta  
Ángela Molina Ruiz  
Víctor Montesinos Llácer  
Emanuela Musumeci  
Sonja Orrigo  
Neus Penalva Martínez  
Ana Ros García  
María Amparo Tórtola Baixauli  
Agnese Tolino  
Bryan Zaldívar Montero  
Josu Hernández García  
Nuria Falcó Moreno  
Miguel García Folgado

# T

he Equality and Diversity Commission (CID) arises from the Office of Young Researchers, Gender and Diversity, created in October 2017, and whose original functions were divided between the CID and the Office of Young Researchers (OJI). The objective of the CID is to try to eliminate discrimination or harassment that may take place in the Institute, ensuring equal opportunities for all its members and promoting good relations between the components of all its sections.

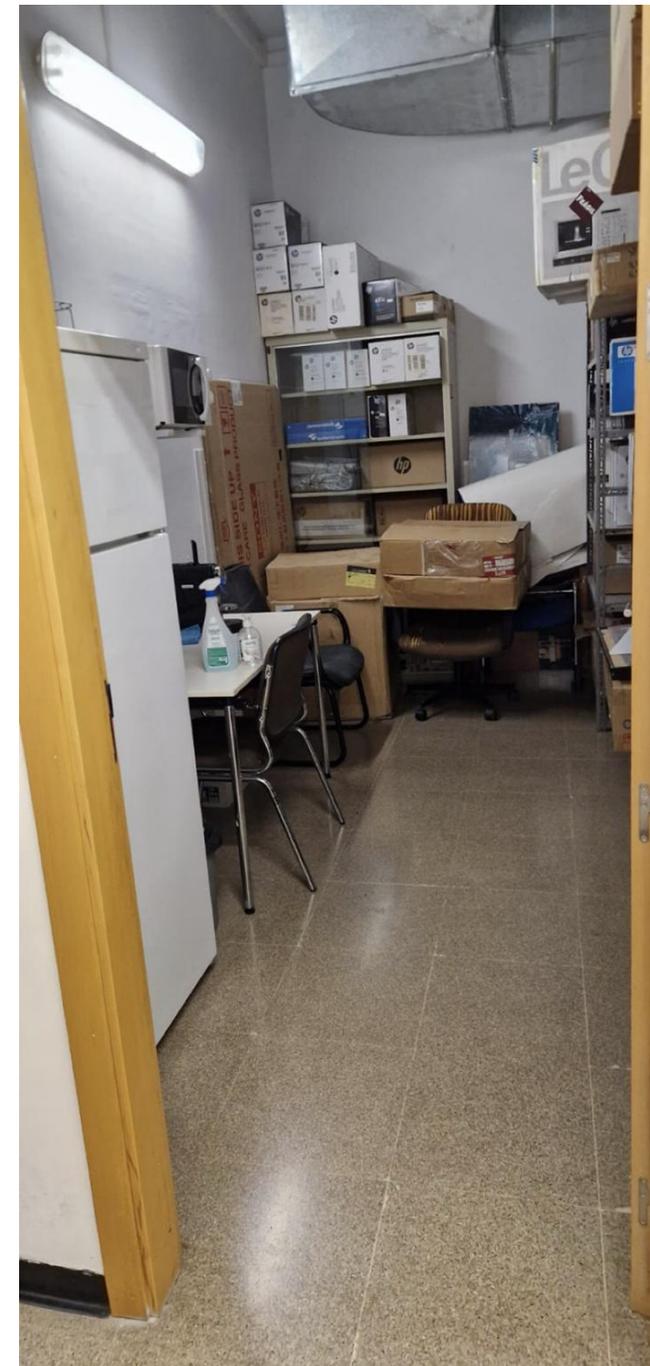
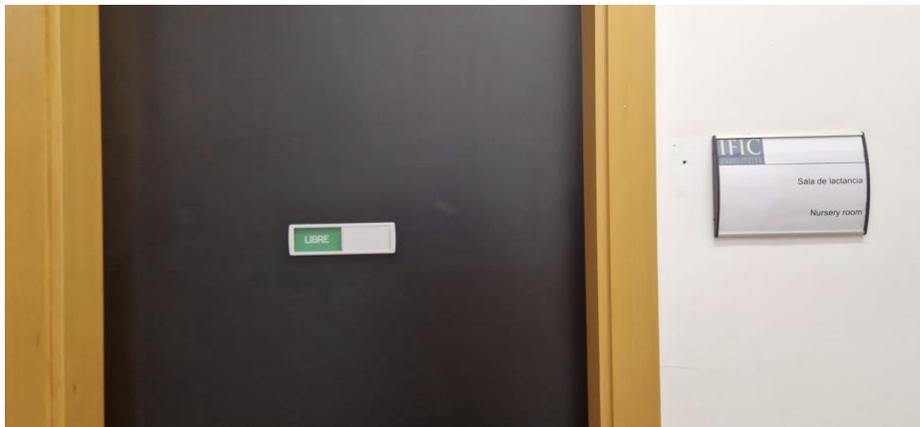
In 2022, IFIC was awarded with the “Distintivo de Igualdad del CSIC” in recognition to the work done by the Institute to reach a real equality between men and women.

# 10 CID ACTIVITIES AND EVENTS

## SALA DE LACTANCIA EN EL IFIC

In March 2023, a space enabled by IFIC as a temporary lactation room came into operation. This space, which meets the minimum privacy and hygiene conditions required for a lactation room, is not exclusively designated for this purpose and does not have ideal conditions. Nevertheless, it has been a highly efficient solution for four women from the Science Park (users from IFIC, ICMUV, ICBIBE, IATA) since its inauguration in March 2023.

Throughout 2023, the CID continued to promote the construction of a dedicated lactation room in the Science Park.



# 10 CID ACTIVITIES AND EVENTS

24 de noviembre

CODO con CODO 2023



Por la eliminación de la violencia contra la mujer

**Lugar de encuentro** - Pasillo común de los Institutos de Investigación de Paterna, planta baja del edificio, pasillos laterales.

**Hora** - 12:00 h. de la mañana, viernes 24 de noviembre.

IFIC CID Os esperamos a tod@s CSIC



## 8 M: Discriminaciones en la carrera científica

**8M DIA INTERNACIONAL DE LA MUJER**  
**8 de Marzo | 11.00 h**  
**Salón de actos del IATA**

- 10.30 h | Café de bienvenida
- 11.00 h | Empoderamiento y calidad de vida
- 12.00 h | Mesa redonda: Discriminaciones sociales y culturales en la carrera científica

Panelists: Rocio Pérez (Cofundadora de la Start-Up Bidhaa Sasa), Alicia Reyes (IATA), Sonja Orrigo (IFIC), Maria Dzunkova (I2SYSBIO), and Delia Bellezza (ICMol).

Logos: IFIC, I2SYSBIO, ICMOL, IATA, EXCELENCIA SEVERO OCHOA

As every year, for International Women's Day, IFIC organized an event in collaboration with other Institutes of the Scientific Parc. Rocío Pérez, physicist and cofounder of the start-up Bicha Sasa, gave a seminar on 'Empowerment and quality of life'. The seminar was followed by a roundtable on 'Social and cultural discrimination in scientific career', with panelists Rocío Pérez, Alicia Reyes (IATA), Sonja Orrigo (IFIC), Maria Dzunkova (I2SysBio) and Delia Bellezza (ICMol).

## 25 N: Día internacional de la eliminación de la violencia contra la mujer

IFIC carried out the 'Codo con codo' activity, a gathering in the IFIC hallway as a protest against violence against women (2022, 2023).

In addition, this year the initiative 'Write Your Phrase' was introduced, in which several sheets were placed in the hallways along with a mural on the central walkway for Institute staff to write down sexist comments they had received in the academic environment.

Examples received:  
 "At a conference: Since you've published so many articles, I thought you were a man"  
 "You should give the plenary talk instead. It's always nicer to see a pretty face"



# 10 CID ACTIVITIES AND EVENTS



## 11 F: INTERNATIONAL DAY OF WOMEN AND GIRLS IN SCIENCE

### 11F: Conferences in High Schools

7 IFIC researchers gave a series of talks, 11 in total, in different secondary schools in the Valencian Community.



### 11F: Masterclass on Particle Physics

Close to 70 female students from 25 High School institutes around the Valencian Community participated in this one-day hands-on activity. Starting with introductory lectures to theory and experiments in High Energy Physics and continuing with a 2-hour practical session where they analyse real data from the ATLAS experiment, students experience what being a scientist is. All lectures are given by IFIC female researchers, including an open discussion on Women in Science.

This activity is organized by the International Particle Physics Outreach Group (IPPOG) and done simultaneously in several research centres along the Globe.



# 10 CID ACTIVITIES AND EVENTS

## 'PIONERAS' EXPOSITIONS

During the year 2023, the 'Pioneras' collection has been exhibited in several locations. The 'Pioneras' exhibition by Proyecto Meitner is an initiative for promoting science and gender awareness, driven by IFIC. It brings together the winning and selected works from the three editions of the 'Express-Arte ConCiencia' competition and includes a collection of original works by interdisciplinary artist Monica Mura. Together, the exhibition recovers and reflects the legacy of some of the greatest nuclear scientists through a selection of images and texts.

Exposition at Diputació de València as part of the 11F celebration

Driven by the Vice President of the Valencia Provincial Council, the exhibition was available in the Sala de Reinas of the Valencia Provincial Council from February 6 to 19.



11 

YOUNG  
RESEARCHERS  
OFFICE



# 11 YOUNG RESEARCHERS OFFICE

# T

he mission of the Office of Young Researchers (YRO) is to carry out actions that favour the professional development of doctoral and postdoctoral researchers at IFIC.

## Objectives

The actions carried out by the OJI to fulfil its mission are framed in the development of several activities throughout the academic year aimed at helping new recruits, and to disseminate the skills and abilities acquired by IFIC PhDs in the business world.

1. Programme to help the integration of doctoral and postdoctoral researchers at the institute: Presentation day for new postdocs, in collaboration with the heads of unit, welcome day for master's and doctoral students, etc.
2. Programme to support the integration of PhDs in the workplace: Round table with IFIC PhDs currently working in the world of work, conference with companies, colloquium by an IFIC PhD with a relevant position in a company, ...

**YRO committee**

María Moreno  
Alberto Ramos

# 11 YOUNG RESEARCHERS OFFICE

Along the academic course 2022/2023, the OJI has continued in his mission to help young researchers arriving to the institute.

For this purpose, we have organized a welcome event for postdoctoral researchers: [Newcomers Fest 2023](#).

## Newcomers Fest 2023

miércoles 29 nov. 2023 9:30 → 14:00 Europe/Madrid

Salón de Actos del Edificio de Cabecera del Parque Científico



In this even researchers that join the IFIC have the opportunity to present his/her line of research to the members of the institute as well as to their fellow newcomers. The event also includes some key talks by the Director of the institute to help newcomers to get a picture of the different research activities carried in the institute.

In a similar fashion the OJI has organized a [welcome event for the new PhD students](#). In this event new students know each other, present their background, interests and hobbies. Special lectures by the Director of the Institute and by the coordinator of the PhD program help the students understand what is expected from a PhD student at IFIC, and what are the steps that they need to follow in order to get a Doctor degree.

## PhD welcome session 2023

miércoles 22 nov. 2023 10:00 → 13:30 Europe/Madrid

Salón de Actos del Edificio de Cabecera del Parque Científico

Moreover the OJI in collaboration with the professional development office of the

University and the UCIE (technology transfer office), have been preparing an event with companies to show on one hand, the kind of work that the private sector can offer to a researcher from IFIC, and on the other hand to show the companies the abilities that a typical IFIC researcher has.

12



# SUSTAINABILITY COMMISSION



# 12 SUSTAINABILITY COMMISSION

# T

he mission of the Sustainability Commission of IFIC is to identify and implement actions that enhance the environmental performance of the institute, promoting sustainable practices across all activities.

The actions carried out by the Sustainability Commission to fulfill its mission are structured around several key objectives aimed at fostering environmental responsibility within the institute:

- Identify opportunities to enhance the institute's environmental practices and propose or participate in actions for their implementation.
- Encourage sustainable transportation methods, particularly for commutes to and from the institute.
- Decrease the amount of waste generated through daily activities, with a focus on minimizing the use of plastic within the center and the cafeteria.
- Reduce the institute's carbon footprint through improved insulation, the use of renewable energy sources, and process optimization.

## **SOS committee**

Sara Cárcel  
Ana I. Delgado  
Javier Gallego  
Fernando Hueso

# 12 SUSTAINABILITY COMMISSION

In 2023, the Sustainability Commission at IFIC undertook numerous initiatives aimed at reducing the environmental impact of the institute and fostering sustainable practices among staff and students. Below is a summary of the achieved, incomplete, and pending actions.

## Achieved Actions

- Replaced plastic bottles with glass bottles in two campus cafeterias.
- Offered a €0.6 discount on the cafeteria menu for bringing a personal water bottle (currently available in one cafeteria, with plans to extend to a second).
- Installed seven new filtered and refrigerated water fountains for refilling.
- Eliminated one large plastic water jug fountain.
- Supported the Parc Científic's [awareness campaign](#) on using water fountains, offering corporate prizes.
- Converted six previously paper-based forms/processes to digital formats.
- Requested and implemented the option to attach files in the IRT ticket service for better administrative logistics.
- Designed a [CSIC contract calculator](#).
- Reduced printed pages by 10% following a campaign encouraging reduced printing.

- Tested switching from white to recycled paper in printers.
- Created a map of available showers for cyclists and successfully petitioned for more efficient water heaters (aerotherms).
- Conducted a survey to identify main obstacles for cycling among IFIC staff.
- Promoted the sustainable market organized by ETSE.
- Requested and secured safer bike racks, which have been installed.
- Presented annual results at the center's annual assembly ([link to presentation](#)).
- Joined UV sustainability working groups and held meetings with the Vice-Rector for Sustainability.

## Incomplete or Unsuccessful Actions

- A campaign to extend the municipal bus route to IFIC included a meeting with the City Council but yielded no results.
- A €100,000 funding application submitted to the Valencia City Council for installing solar panels and researching green roof technology was not granted.
- Despite improved bike racks and security cameras, bike thefts have occurred.
- Requested additional trees along campus sidewalks to reduce the urban heat island effect, but the request was not approved.

- Proposed a 50/50 reinvestment model where savings would fund further sustainability initiatives; however, this has not yet been evaluated by UV.

## Pending Actions

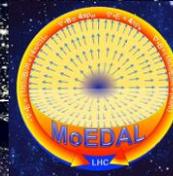
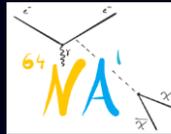
- Place recycling bins in locations where they are currently missing.
- Extend the use of recycled paper to all printers within the center.
- Replace traditional bulbs with LED alternatives.
- Improve the thermal envelope insulation of the building.
- Implement a remote computer access system to support telecommuting.
- Ensure that vegetarian options are consistently available in cafeterias.
- Promote carpooling using [Hoop Carpool](#).
- Install lockers and drying racks near showers for cyclists.
- Organize guided bike commutes and provide cafeteria discounts for participants.
- Request better tram service (frequency, traffic light priority).
- Explore options for monthly deliveries of organic or local food baskets.
- Lobby for improved long-distance European train services (night trains, EU representation, press releases, etc.).

13 

FUNDING



# 13 PROJECTS

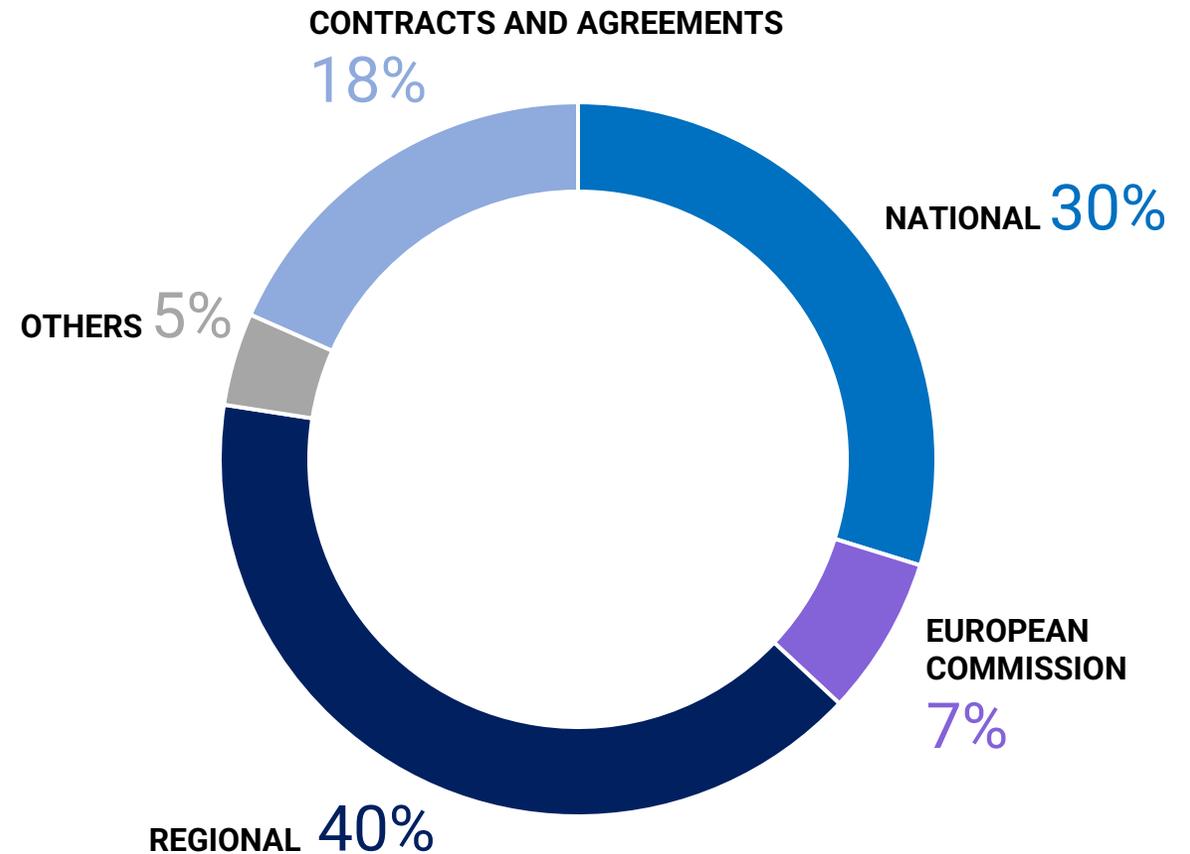


\* Map of experimental collaborations in fundamental physics with IFIC's participation

# 13 TOTAL INCOME BY SOURCE

<u>NATIONAL PROJECTS</u>	5,180,272.33 €
<u>EUROPEAN PROJECTS</u>	1,249,888.86 €
<u>REGIONAL PROJECTS</u>	7,032,600.17 €
<u>OTHER PROJECTS</u>	729,885.67 €
<u>CONTRACTS AND AGREEMENTS</u>	3,191,144.83 €

**TOTAL 17,383,791.86 €**



[Full list of grants](#)



# ANNEXES



# 1 Personnel List

## Permanent staff researchers: 74

Albiol Colomer, Francisco Javier  
Algora, Alejandro  
Alvarez Ruso, Luis  
Barenboim, Gabriela  
Bordes Villagrasa, José Manuel  
Botella Olcina, Francisco J.  
Cabrera Urbán, Susana  
Campanario Pallás, Francisco  
Cases Ruiz, Ramón  
Castillo Giménez, M. Victoria  
Cervera Villanueva, Anselmo  
Cortina Gil, María Dolores  
Costa Mezquita, María José  
Díaz Medina, José  
Domingo Pardo, César  
Donini, Andrea  
Fabbri, Alessandro  
Fiorini, Luca  
Fuster Verdú, Juan A.  
Gadea Raga, Andrés  
García García, Carmen  
García Navarro, José Enrique  
Gimeno Martínez, Benito  
González de la Hoz, Santiago  
González Marhuenda, Pedro  
Hernández Gamazo, Pilar  
Hernández Rey, Juan Jose  
Herrero García, Juan Andrés  
Hirsch, Martin

Lacasta LLacer, Carlos  
Lledó Barrena, M<sup>a</sup> Antonia  
Llosá Llácer, Gabriela  
Martí García, Salvador  
Martínez Vidal, Fernando  
Mena Requejo, Olga  
Mitsou, Vasiliki  
Molina Peralta, Raquel  
Nácher González, Enriquer  
Navarro Salas, José  
Nebot Gómez, Miguel  
Nieves Pamplona, Juan Miguel  
Noguera Puchol, Santiago  
Novella Garijo, Pau  
Olmo Alba, Gonzalo  
Oyanguren Campos, Arantza  
Palomares Ruiz, Sergio  
Papavassiliou, Ioannis  
Pastor Carpi, Sergio  
Pérez Cañellas, Armando  
Pich Zardoya, Antonio  
Portoles Ibañez, Jorge  
Rius Dionis, Nuria  
Rodrigo García, Germán  
Rubio Barroso, Berta  
Ruiz de Austri Bazan, Roberto  
Ruiz Martínez, Arantxa  
Salt Cairols, José  
Sanchis Lozano, Miguel Angel  
Santamaría Luna, Arcadi  
Sanz González, Veronica

Sorel, Michel  
Taín Enríquez, José Luis  
Tarifeño Saldivia, Ariel  
Tortola Baixauli, M<sup>a</sup> Amparo  
Valls Ferrer, Juan Antonio  
Velasco González, Jorge  
Vicente Vacas, Manuel  
Vidal Perona, Jorge  
Vijande Asenjo, Javier  
Vives García, Oscar  
Vos, Marcel  
Yahlali Haddou, Nadia  
Zornoza Gómez, Juan de Dios  
Zuñiga Román, Juan

## Tenure-track researchers: 29

Albaladejo Serrano, Miguel  
Cieri, Leandro Javier  
De Romeri, Valentina  
Escobar Ibáñez, Carlos  
Esperante Pereira, Daniel  
Figueroa, Daniel G.  
García Cely, Camilo Alfredo  
Gessner, Manuel  
González Alonso, Martín  
Gozzini, Sara Rebecca  
Gross, Christian  
Hagedorn, Claudia  
Irlés Quiles, Adrian  
Lopez March, Neus  
Lopez Pavon, Jacobo

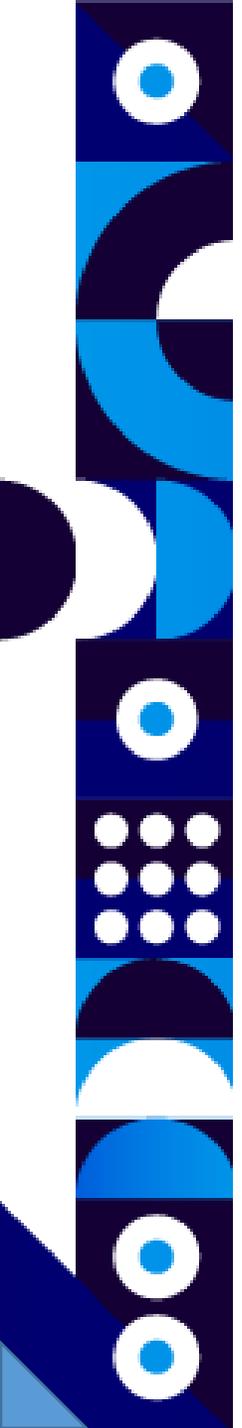
Mariñas Pardo, Carlos Manuel  
Martín-Albo Simón, Justo  
Molina Bueno, Laura  
Moreno Llácer, María  
Passemar, Emilie  
Poveda Torres, Joaquin  
Ramos Martínez, Alberto  
Salesa Greus, Francisco  
Sanchez Losa, Agustin  
Torró Pastor, Emma  
Vicente Montesinos, Avelino  
Villaplana Pérez, Miguel  
Zaldívar Montero, Bryan  
Zurita, José Francisco

## Professors emeriti and visiting researchers: 10

Azcárraga Feliu, José Adolfo de  
Bernabéu Alberola, José  
Fassi Imlahi, Farida  
Ferrario, Paola  
Ferrer Soria, Antonio  
Furtado Valle, José Wagner  
Higón Rodríguez, Emilio  
Oset Báguena, Eulogio  
Peñarrocha Gantes, José Antonio  
Vento Torres, Vicente

## Post-doctoral researchers: 56

Ardu, Marco  
Babiano Suarez, Victor



# 1

Balibrea Correa, Javier  
Berbig, Maximilian  
Bhattacharya, Arunima  
Boronat Arevalo, Marça  
Caballero Ontanaya, Luis  
Cantero García, Josu  
Carrió Argos, Fernando  
Cecchini, Vincent  
Coutinho, Antonio Manuel  
Curcio, Francesco  
Da Silva Leite, Julio Rafael  
Del Rio Vega, Adrian  
Dhani, Prasanna Kumar  
Ferreiro de Aguiar, Antonio Eduardo  
Fuster Martinez, Nuria  
Garcia Folgado, Miguel  
García Soto, Alfonso Andrés  
Gargalionis, Johnathon  
Giménez Alventosa, Vicent  
Gupta, Aritra  
Hati, Chandan  
Hernandez Garcia, Josu  
Hueso Gonzalez, Fernando  
Karan, Anirban  
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Lang, Nicolas  
Lerendegui Marco, Jorge  
Martín Lozano, Víctor  
Mehrabankar, Somayeh  
Melini, Davide

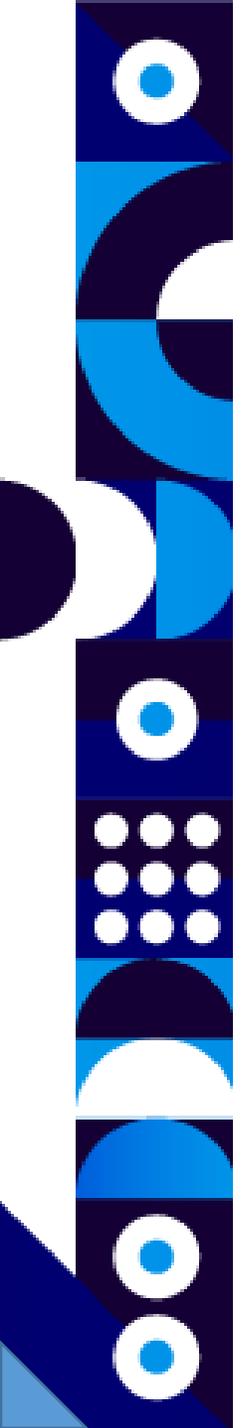
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Nath, Newton  
Novoa Brunet, Martín Rodrigo  
Orrigo, Sonja Elena Agata  
Perez Vidal, Rosa Maria  
Pérez Poyatos, José María  
Rahat, Moinul Hossain  
Ros Garcia, Ana  
Rosario Bonastre, Ivan  
Saibel, Andrej  
Salas Bernardez, Alexandre  
Sánchez García, Gonzalo  
Sanderswood, Izaac Gregory  
Shergold, Jack David  
Shi, Pan Pan  
Simakachorn, Peera  
Soares Narciso Ferreira, Antonio  
Mauricio  
Soto Oton, Jose Alfonso  
Staelens, Michael Anthony  
Torrentí Salom, Francisco  
Tortajada Velert, Salvador  
Vale Silva, Luiz Henrique  
Wang, Deng  
Zakareishvili, Tamar

## PhD students: 99

Agius, Dominic Alfred Klaus  
Aikot, Arya  
Albandea Jordan, David  
Alcala Escalona, Gustavo Adolfo  
Almanza Soto, Melissa

Alvarado Alvarez, Fernando  
Alves Garre, Sergio  
Amar Es-Sghir, Hamza  
Amerio, Aurelio  
Amos, Kieran  
Autieri, Andrea  
Baeza Ballesteros, Jorge Juan  
Bariago Quintana, Adriana  
Bas Beneito, Arnau  
Beltrán Lloría, Rebeca  
Bernardino Gameiro, Bernardo  
Bouchhar, Naseem  
Capó Torres, Jordi  
Carrasco Mejía, Juliana Mara  
Cervelló Duato, Antonio  
Chitishvili, Mariam  
Conde Villatoro, Daniel Eduardo  
Coro, Federico  
De la Cruz Alzaga, Sergio  
De la Fuente Rosales, Gabriel  
Di Meglio, Francesco Paolo  
Didenko, Mariia  
Dimitriou, Androniki  
Dávila Illán, Juan Manuel  
Díaz Calderón, David  
Escalante Castro, José Manuel  
Esser, Fabian  
Fernández Ortega, Juan Carlos  
Ferrando Solera, Sergio  
Fonseca Vargas, Angie Carolina  
García Lorenzo, Amador  
García Martínez, Irene

Gil Dominguez, Fernando  
Gomez Delegido, Antonio Jesus  
Gómez Lurbe, Rafael  
Hajjar Muñoz, Rasmi Enrique  
Herrero Brocal, Antonio  
Jiménez Ortega, Miguel  
Kellerer, Fabian  
Lanzac Berrocal, Marta  
Lazo Pedrajas, Alfonso  
Lessing, Nadja  
Libralon, Simone  
Loayza Romero, Nicolas  
Martinez Agulló, Pablo  
Martinez Reviriego, Pablo  
Martín Luna, Pablo  
Martínez de Lejarza Samper, Jorge  
Juan  
Martínez López, Eduardo  
Medina Rosales, Omar  
Miró Arenas, Carlos  
Monsonis Romero, Luis  
Montesinos Llácer, Víctor  
Musumeci, Emanuela  
Muñoz Candela, Pablo  
Muñoz Ovalle, Alejandro  
Muñoz Perez, David  
Márquez Hernández, Jesús Pedro  
Nadal Gisbert, Sergi  
Navarro Gonzalez, Josep  
Palacios Gonzalez, Juan  
Parra Aedo, Selene Bárbara  
Pastor Gómez, Emilio Jesús



# 1

Pattnaik, Baibhab  
Pedraza Motavita, Laura Karina  
Pepin, Julien  
Pompa, Federica  
Prades Ibañez, Alberto  
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Pérez Soler, Javier  
Rebollo de Miguel, Miguel  
Reina Valero, José  
Renteria Estrada, David Francisco  
Renteria Olivo, Andres Ernesto  
Rodríguez García, David  
Rubio Jiménez, Adrián  
Saina, Adrian  
Sanchez Sebastian, Victoria  
Senthilkumar, Varsha  
Simeó Vinaixa, Mireia  
Sánchez Blázquez, Lucia  
Sánchez Muñoz, Julián Andrés  
Telo Rodrigues Catumba, Guilherme  
Terrones Aragón, Adrián  
Tolino, Agnese  
Tuzi, Mirald  
Ureña González, Julio  
Urrea González, Salvador  
Valiente Moreno, Enrique  
Varriale, Lorenzo  
Vatsyayan, Drona  
Viegas Botelho Correia Rego, Rita  
Vincent, Morvan

Zhuo, Jiahui

## Technical staff: 65

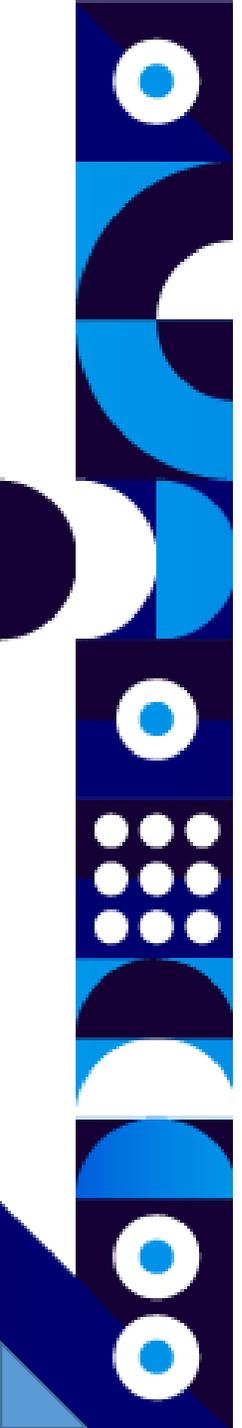
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Bernabeu Verdú, José  
Blanch Gutierrez, Cesar  
Blasco Gil, Pablo Agustín  
Blasco Miquel, José  
Brzezinski, Karol Wiktor  
Burriel Navarro, Helena  
Calvo Diaz-Aldagalán, David  
Camarasa Domene, Miriam  
Capilla Fernández, Elvira  
Carrasco de Fez, Rosa  
Casaña Copado, Jose Vicente  
Civera Navarrete, José Vicente  
Cámara García, María Teresa  
Delgado Belmar, Ana Isabel  
Elesgaray Susierra, Oihan  
Esteban Ferrer, Guillermo  
Fernández Casaní, Álvaro  
Ferrero Yanini, Luis  
Fuentes Castilla, Angel  
G. B., Adrián  
Gallego Baviera, Francisco Javier  
Giner Llorens, Carlos  
Gonzalez Iglesias, Daniel  
González González, Francisco  
Gutiérrez Arance, Héctor  
Hernández Navalón, David  
Hervás Álvarez, Francisco  
Kholoimov, Valerii

Ladarescu Palivan, Ion  
Lopez Redondo, Manuel  
López López, Hanlez  
Manzaneda García, Mario  
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Platero Montagut, Vicente  
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Roche Fernández, Andrea  
Rodriguez Cespedosa, Nicolas  
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Sanchis Pérez, Héctor  
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Solaz Contell, Carles  
Soldevila Serrano, Urmila  
Svintozelskyi, Volodymyr  
Sánchez Martínez, Fco. Javier  
Sánchez Vargas, Alberto  
Tchogna Davis, Daniel  
Teruel Pardo, Simón  
Uzum, Roberto Andreeas  
Valero Biot, José Alberto  
Valori, Nicola  
Vico Gil, Santiago

Villena Cabañero, Francisco Higinio  
Villodre Martínez, Santiago  
Yang, Liang Liang  
Álvarez Puerta, Jesús

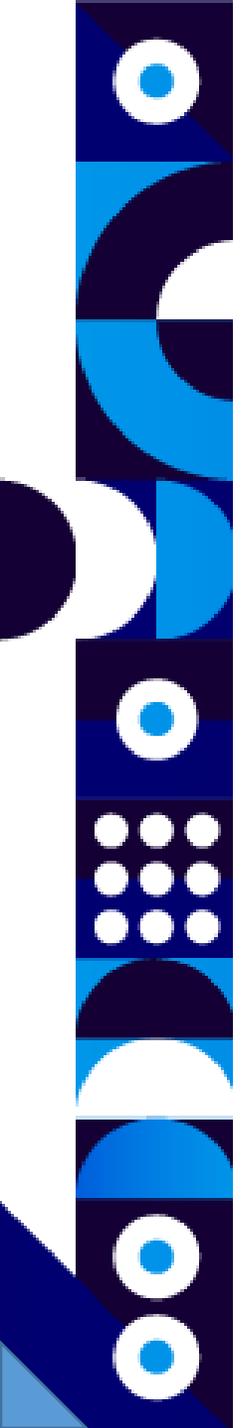
## Administrative staff: 22

Aguilar Argilés, Teresa  
Andreu Garcia, M<sup>a</sup> Teresa  
Araque Elvira, Maria Teresa  
Claramunt Pedrón, Luis Miguel  
Falcó Moreno, Nuria  
Fandos Lario, Ana María  
Ferrer Lazaro, Jose Manuel  
Fillol Lacruz, Raquel  
Fillol Ricart, Amparo  
Garcia Gonzalez, Soledad  
Gonzalez Romeu, Maria Teresa  
Gracia Vidal, Maria Jose  
Hernando Recuero, Maria Luisa  
Molina Ruiz, Angela  
Monserate Fandos, María  
Montesinos Reig, Leonor  
Monzón Herrero, Benjamín  
Novo Picouto, José Carlos  
Pérez García, José  
Rubiera Prats, Chabely  
Salgado Lopez, Oscar  
Taberner Ubeda, M<sup>a</sup> Eva



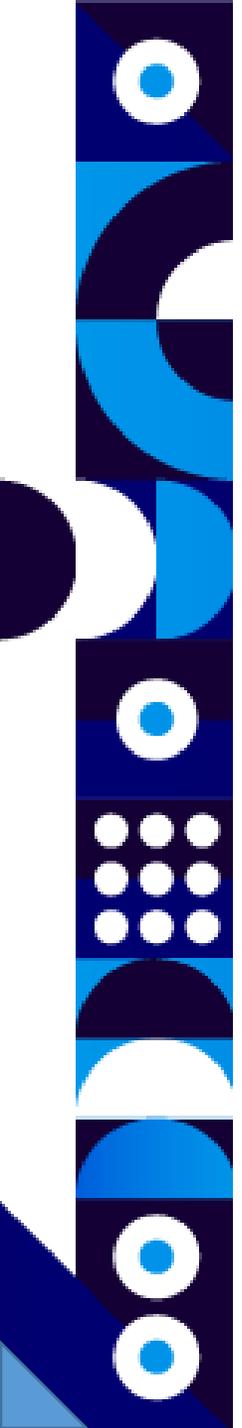
## 2 Publications

[The full list of scientific publications in 2023 is available at the IFIC Literature Database](#)



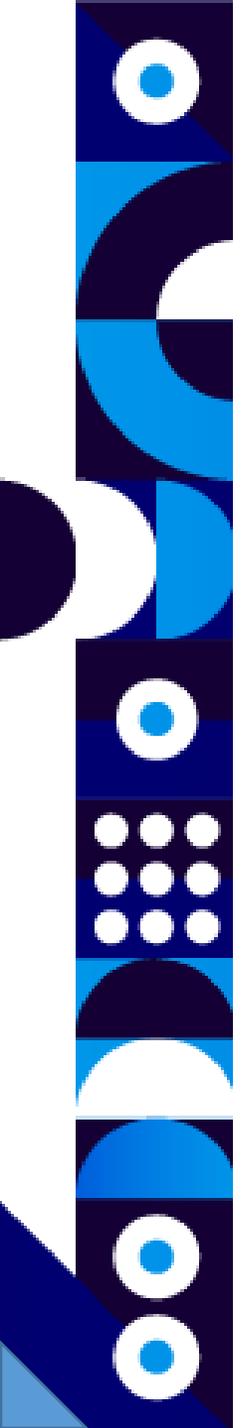
# 3 Conferences and workshops organized

- [7th Winter Workshop @ Valencia](#), Dec 11-13
- [IV Jornadas RSEF / IFIMED de Física Médica](#), Nov 29 – Dec 1
- [General n TOF Collaboration Annual Meeting](#), Nov 22-24
- [Quantum Observables for Collider Physics](#), Nov 6
- [3<sup>rd</sup> COMCHA School](#), Oct 23-31
- [Analysis Preservation BootCamp @ Valencia](#), Oct 16-18
- [L International Meeting on Fundamental Physics and XV CPAN days](#), Oct 2-6
- [Experimental Workshop on Top-Quark Mass Measurements](#), Sep 20
- [BRAPHYQS Collaboration Meeting](#), Sep 19-20
- [First EuCAPT School: Cosmology](#), Sep 18-22
- [12<sup>th</sup> International Workshop on the CKM Unitarity Triangle \(CKM 2023\)](#), Sep 18-22
- [Parton distribution functions at a crossroad](#), Sep 18-22
- [Strong 2020 Hadron Spectroscopy School](#), Sep 5-14
- [ATLAS Hadronic Calibration Workshop \(HCW23\)](#), Sep 4-8
- [VII Jornada de la Mujer Investigadora](#), May 19
- [7th Red LHC Workshop](#), May 10-12



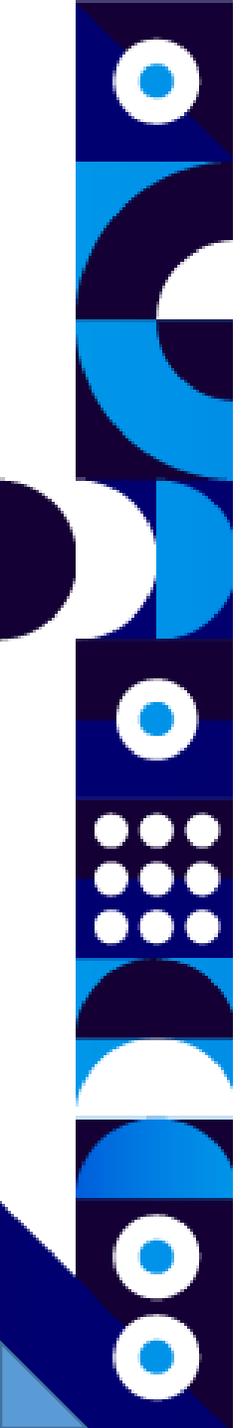
# 3 Conferences and workshops organized

- [HALC LHC 23 -- Highest accuracy perturbative predictions at the lowest computational consumption for LHC phenomenology](#), Apr 25-28
- [KM3NeT Oscillation Workshop](#), Apr 18-21
- [Trigger and readout at the LHC experiments for Run 3 and beyond in Spain - COMCHA](#), Mar 20-22
- [Jornadas de la Red Española de Futuros Colisionadores](#), Mar 8
- [Jornadas de Ciencia y Género Proyecto Meitner](#), Feb 28 – Mar 2
- [Workshop CSIC Strategic Theme "Understanding the basic components of the Universe, its structure and evolution"](#), Feb 22-23



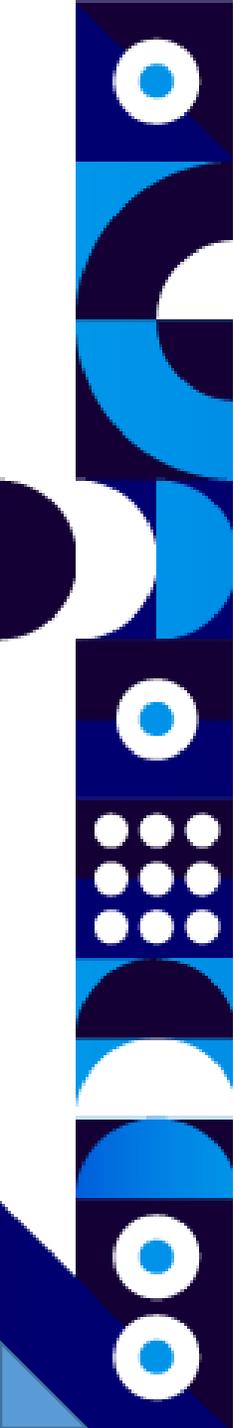
# 4 Colloquia organized

- [Andreas Ringwald, "The quest for the axion"](#), Nov 23
- [Luis Ibáñez, "The quantum gravity swampland and particle physics"](#), Oct 26
- [Katerina Lipka, "Jets and proton structure at the LHC"](#), Sep 21
- [Galileo Violini, "A synchrotron in the Great Caribbean"](#), Jul 12
- [Alfonso Jaramillo, "Engineering learning in bacteria: a crossroads of physics and biology"](#), Jun 8
- [Bernard J. T. Jones, "Cosmic inflation in the past and today"](#), May 18
- [Hartmut Wittig, "The muon anomalous magnetic moment and the role of Lattice QCD"](#), Apr 27
- [Anna Muro Rodríguez, "Well-being and positive mental health in research career"](#), Mar 30
- [Juan Fuster, "Accelerators: instruments for research and for society"](#), Feb 16
- [Michele Maggiore, "Fundamental physics and cosmology with the Einstein Telescope"](#), Jan 19



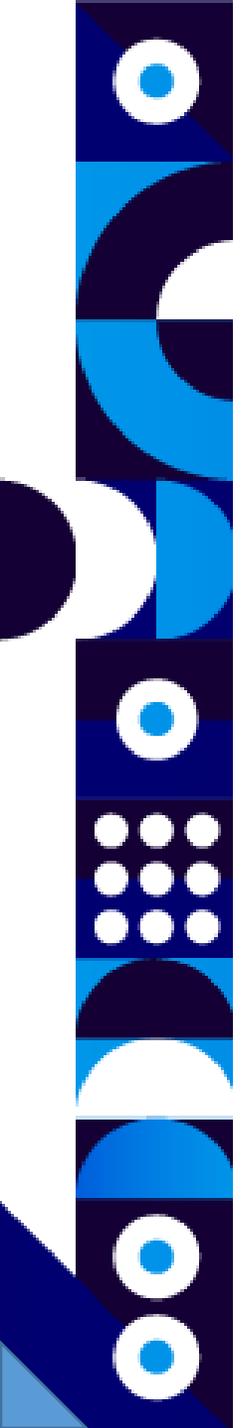
# 5 Seminars organized

- 18 Dec [Sebastian Tattenberg, "se-fis-med: Benefits of range uncertainty reductions in proton therapy and interplay with proton arc therapy implementation"](#)
- 18 Dec [Helena García, "Topical Seminar: Solving the riddle: Visible in the laboratory and invisible in cosmology: Decaying sterile neutrinos"](#)
- 14 Dec [Sanjoy Mandal, "Topical Seminar: Probing origin of neutrino masses through low and high energy processes"](#)
- 14 Dec [Kieran Amos, "#StudentSeminar: Search for lepton-flavour-violating decays of the Higgs Boson and measurement of off-diagonal Yukawa coupling with the ATLAS detector"](#)
- 13 Dec [Mathias Becker, "Topical Seminar: Production of Feebly Interacting Particles at Finite Temperatures"](#)
- 12 Dec [Pier Paolo Giardino, "IFIC Seminar: From Precision Physics to New Physics: Effective Field Theories and Loops"](#)
- 05 Dec [Alejandro Jenkins, "HiDDeN webinar: Cosmology without scalars: Inflation, reheating, and baryogenesis in a superfluorescent Universe"](#)
- 05 Dec [Alberto Roper Pol, "IFIC Seminar: Gravitational wave background produced by turbulence in the early universe"](#)
- 30 Nov [Mario Reig, "Topical Seminar: Searching for axion forces with atoms, molecules, and storage rings"](#)
- 30 Nov [Naseem Bouchhar, "#StudentSeminar: Towards a precise top quark mass measurement: Improved in-situ jet response measurements and interpretation of the Monte Carlo top quark mass parameter"](#)
- 28 Nov [Andrea Mitridate, "IFIC Seminar - Exploring the Gravitational Wave Universe with PTAs: where we are and where we are going"](#)
- 27 Nov [Petros Stefanou, "#StudentSeminar: Modelling force-free neutron star magnetospheres using physics-informed neural networks"](#)
- 24 Nov [Adil Jueid, "Topical Seminar: A possible connection between dark matter and top quark FCNC decays"](#)
- 24 Nov [Pablo Martínez Agulló, "#StudentSeminar: Search for the Higgs boson produced in association with a top quark using  \$\tau\$  leptons with ATLAS"](#)
- 23 Nov [Javier Olivares Herrador, "#StudentSeminar: Beam Loading effect in Linear Accelerators: Simulations and Measurements"](#)



# 5 Seminars organized

- 21 Nov [Maria Vieites Diaz, "IFIC Seminar: Status of the "LHCb flavour anomalies""](#)
- 20 Nov [Carles Gomà, "se-fis-med: La protonteràpia a l'estat espanyol: Horitzó 2030."](#)
- 15 Nov [Miguel Vanvlasselaer, "Topical Seminar: Anomaly-induced neutron star cooling"](#)
- 14 Nov [Javier Menéndez, "IFIC Seminar: Extracting physics beyond the standard model from experiments using atomic nuclei"](#)
- 13 Nov [Takeshi Kobayashi, "Topical seminar: Monopoles and cosmological magnetic fields"](#)
- 08 Nov [Jesús Frías López, "Webinario "Licencias y Transferencia de Resultados""](#)
- 07 Nov [Kevin Zhou, "HiDDeN webinar: Electromagnetism and Gravity with Continuous Spin"](#)
- 07 Nov [Jose Miguel No, "IFIC Seminar: Baryogenesis from extended scalar sectors: off the beaten track"](#)
- 07 Nov [V́ctor Carretero Cuenca, "#StudentSeminar: Measuring neutrino oscillations and probing invisible neutrino decay with KM3NeT/ORCA6"](#)
- 06 Nov [Paul Hsiao, "Topical Seminar: Spectroscopy of chimera baryons: Top partners of a composite Higgs model with Sp\(4\) gauge group"](#)
- 02 Nov [Shahab Joudaki, "Topical Seminar: Revolutionizing fundamental physics using cosmological galaxy surveys"](#)
- 02 Nov [Beatriz Romeo, "#StudentSeminar: Exploring the potential of  \$\gamma\$ -decay to constrain  \$\nu\$ - \$\beta\$ -decay nuclear matrix elements"](#)
- 31 Oct [Andrea Caputo, "IFIC Seminar: Stars and Galaxies, a pathway to the Dark Side of Fundamental Physics"](#)
- 30 Oct [Francesco D'Angelo, "Topical Seminar: Aspects of QCD topology, chiral symmetry and axion phenomenology from lattice simulations"](#)
- 25 Oct [Carlos García Canal, "IFIC Seminar: The Muon puzzle's"](#)
- 23 Oct [Roberto Bruschini, "IFIC Topical Seminar: Double-Heavy Hadron Spectroscopy from QCD"](#)
- 19 Oct [Juan Rojo, "Topical Seminar: Physics with TeV Neutrinos at the LHC"](#)
- 18 Oct [Eleftheria Solomonidi, "#StudentSeminar: "An anomaly in charm or a guesstimate defect? SM calculation of the D meson CP asymmetries"](#)

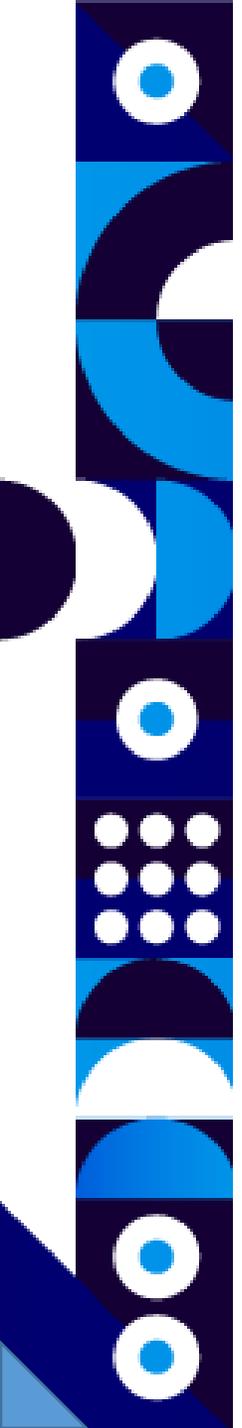


# 5 Seminars organized

- 17 Oct [Miriam Lucio Martinez, "IFIC Seminar: Quantum Computing and High Energy Physics"](#)
- 16 Oct [Emily Draeger, "se-fis-med: Dosimetry in radiobiology and the impact of dosimetric reporting and standardization on study reproducibility"](#)
- 10 Oct [Jishnu Suresh, "IFIC Seminar: Gravitational Wave Orchestra - Being Sensitive is Crucial!"](#)
- 06 Oct [Toni Bertólez, "Topical Seminar: What is the origin of the ANITA-IV events? Synergies between UHE experiments"](#)
- 05 Oct [Martín Novoa Brunet, "Topical Seminar:  \$b \rightarrow s\nu\nu\$  in the SMEFT and \(G\)MFV in light of new Belle II results"](#)
- 04 Oct [Biswajit Karmakar, "IFIC Topical Seminar: Phenomenology of discrete flavor symmetries beyond neutrino masses and mixing"](#)
- 03 Oct [Caner Unal, "IFIC Seminar: Axions in early and late universe"](#)
- 02 Oct [Ipsita Ray, "IFIC Topical Seminar: The CKM phenomenology and some new physics sensitivities"](#)
- 29 Sep [Upalaparna Banerjee, "IFIC Topical Seminar: Recent Advances in Phenomenology with Effective Field Theory"](#)
- 27 Sep [David Díaz Calderón, "#StudentSeminar: New Physics in Hadronic Tau Decays"](#)
- 26 Sep [Werner Porod, "IFIC Seminar: Phenomenology of Composite Higgs Models with a fermionic UV completion"](#)
- 25 Sep [Yasaman Farzan, "Topical Seminar: Constraints from the duration of supernova neutrino burst on resonant light gauge boson production by neutrinos"](#)
- 22 Sep [Carlos Argüelles, "IFIC Topical \(& informal\) Seminar: News from the IceCube Neutrino Observatory and Related Phenomenology"](#)
- 22 Sep [Josep Navarro González, "#StudentSeminar: Searches for new physics in processes involving top quarks with the ATLAS experiment."](#)
- 19 Sep [Valerie Domcke, "HiDDeN webinar: Gravitational waves from metastable cosmic strings"](#)
- 19 Sep [Sebastian Wuchterl, "IFIC Seminar: Probing the top quark mass using  \$tt\$ +jet production at the LHC"](#)
- 13 Sep [George Wei-Shu Hou, "IFIC Topical Seminar: CP Violation for the Heavens and the Earth"](#)

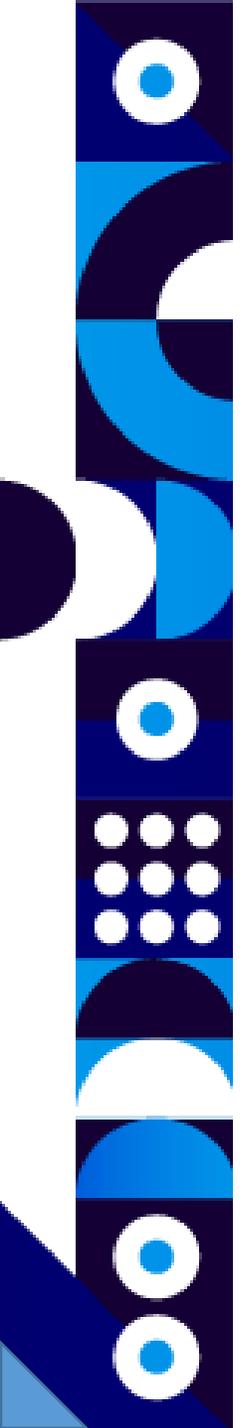
# 5 Seminars organized

- 12 Sep [Igor Danilkin, "IFIC Seminar: Coupled-channel dispersive analysis of  \$\pi\pi/KK\$  scattering and its application to  \$J/\psi\pi\pi\(KK\)\$  and  \$\(g-2\)\_\mu\$ "](#)
- 07 Sep [Jan Heisig, "Topical Seminar: From coannihilation to conversion-driven freeze-out: Dark matter genesis beyond the WIMP paradigm"](#)
- 05 Sep [Kensuke Akita, "IFIC Seminar: Constraints on dark matter-neutrino scattering from the Milky-Way satellites and subhalo modeling for dark acoustic oscillations"](#)
- 28 Jul [Alberto Prades, "#StudentSeminar: The top quark mass: An introduction to its importance, measurement methods, and ongoing developments"](#)
- 27 Jul [Stefano Bertoldo, "#StudentSeminar: New technologies for High Purity Germanium detectors"](#)
- 25 Jul [Arsenii Titov, "IFIC Seminar: Modular invariance and the QCD angle"](#)
- 18 Jul [Tripurari Srivastava, "IFIC Seminar: Resonant leptogenesis in \(2,2\) inverse see-saw realisation"](#)
- 12 Jul [V́ctor Bresó Pla, "#StudentSeminar: New physics searches with the SMEFT"](#)
- 11 Jul [Chandan Hati, "IFIC Seminar: Probing Lepton Number Violation Using High and Low Energy Observables"](#)
- 11 Jul [Sergio Alves Garre, "#StudentSeminar: Disentangling the Origin of High Energy Cosmic Rays from the Mediterranean Abyss"](#)
- 06 Jul [Antonio Otal Palací, "#StudentSeminar: Applicator Reconstruction in Gynecological Brachytherapy on MRI"](#)
- 04 Jul [Marco Fedele, "IFIC Seminar: New Physics in B decays: bugs of features?"](#)
- 30 Jun [Andre Hoang, "Topical Seminar: The CIPT-FOPT discrepancy for hadronic tau decays"](#)
- 29 Jun [Ángel Murcia, "Topical Seminar: On the characterization of Generalized Quasitopological Gravities"](#)
- 21 Jun [Ramón Serrano, "#StudentSeminar: Bancroft's GPS navigation solution: relativistic interpretation"](#)
- 20 Jun [Nathaniel Sherrill, "IFIC Seminar: Constraints on fundamental constant variations from atomic clocks"](#)
- 19 Jun [Marta Anguiano, "se-fis-med: Validación del código de simulación Monte Carlo PENH para haces de protones de uso clínico: comparación con datos experimentales"](#)
- 15 Jun [Christoph Andreas Ternes, "Topical Seminar: Current status of neutrino oscillation anomalies"](#)



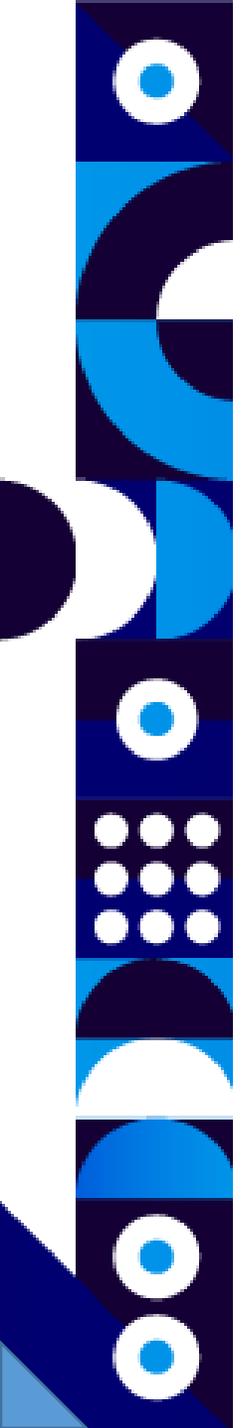
## 5 Seminars organized

- 14 Jun [Marina Borja-Lloret, "#StudentSeminar: Background studies in MACACO for protontherapy."](#)
- 13 Jun [Manibrata Sen, "HiDDeN webinar: Opening the chamber of secrets to revive the sterile neutrino dark matter"](#)
- 13 Jun [Steve King, "IFIC Seminar: Littlest Seesaw Models"](#)
- 12 Jun [Manuel Morales, "Topical Seminar: Parton distributions in the SMEFT"](#)
- 08 Jun [Stefan Sandner, "#StudentSeminar: Right-handed neutrinos and the baryon asymmetry."](#)
- 07 Jun [Mario Fernández Navarro, "Topical Seminar: Tri-hypercharge: a family non-universal path to the origin of flavour"](#)
- 07 Jun [Pablo Escribano, "#StudentSeminar: Collider Searches for Heavy Neutral Leptons: beyond simplified scenarios"](#)
- 01 Jun [Tomasz Dutka, "Topical Seminar: Bubble-assisted Leptogenesis"](#)
- 31 May [Adrián del Río Vega, "BSM Journal Club on "Observational evidence for cosmological coupling of black holes and its implications for an astrophysical source of dark energy", arXiv:2302.07878"](#)
- 25 May [Bryan Zaldivar, "Topical Seminar + Debate: The end of the world? Introduction and discussion about ChatGPT and other generative AI"](#)
- 23 May [Camilo García-Cely, "HiDDeN webinar: Selection rules for the detection of gravitational waves in axion haloscopes"](#)
- 23 May [Miguel Zumalacarregui, "IFIC Seminar: On the propagation of gravitational waves: diffraction, dispersion and birefringence"](#)
- 22 May [Robert Pisarski, "Topical seminar: Two or three things in extreme QCD, especially for cold, dense quarks"](#)
- 19 May [Matteo Fadel, "Topical Seminar: Testing quantum mechanics with 16-microgram Schrödinger cat states"](#)
- 18 May [Andreu Anglés Castillo, "#StudentSeminar: What is real? The ontology of the quantum state through the Einstein-Bohr debate"](#)
- 17 May [Marcos Miralles López, "#StudentSeminar: Measurements of top quark physics observables using LHC data"](#)
- 16 May [Stefano Scopel, "IFIC Seminar: Exploring the WIMP multi-dimensional parameter space with WimPyDD"](#)
- 15 May [Judy Chen, "se-fis-med: Costs of Newly Funded Proton Therapy Using Time-Driven Activity-Based Costing in The Netherlands"](#)



# 5 Seminars organized

- 02 May [Nicolas Lang, "IFIC Seminar: Charmed resonances and exotic matter from QCD"](#)
- 26 Apr [Elisabetta Bossio, "Topical seminar: "Beyond the Standard Model physics searches with double-beta decays and the GERDA experiment ""](#)
- 25 Apr [Stefano Camarda, "IFIC Seminar - Precision measurements of the W boson mass and the most precise measurement of the strong coupling"](#)
- 20 Apr [Malena Tejeda-Yeomans, "Topical Seminar: Hyperons and photons to study the hot, dense, whirly and magnetized matter produced in heavy-ion collisions"](#)
- 20 Apr [Brij Kishor JASHAL, "#StudentSeminar: A GPU based full software trigger for LHCb and tracking algorithms for long-lived particles in Real-Time"](#)
- 19 Apr [Redamy Perez-Ramos, "Topical Seminar: Observation and theoretical explanation of the dead cone effect in QCD charm and bottom quark jets"](#)
- 18 Apr [Nathaniel Craig, "HiDDeN webinar: Muon Colliders as Invisibles Factories"](#)
- 18 Apr [Frank Deppisch, "IFIC Seminar: Quantum sensing neutrinos"](#)
- 05 Apr [#StudentSeminar: Student Seminar Session in Theoretical Physics](#)
- 04 Apr [Victor Martin Lozano, "IFIC Seminar: A new LHC search for dark matter produced via heavy Higgs bosons using simplified models"](#)
- 04 Apr [Miguel Ángel García Peris, "#Student Seminar: ProtoDUNE-SP, a milestone towards CP violation discovery."](#)
- 31 Mar [Michael Schmidt, "Topical Seminar: "Sterile neutrino dark matter from scalar decay""](#)
- 29 Mar [Guilherme Catumba, "BSM Journal Club on the strong CP problem \(part II\)"](#)
- 29 Mar [Antonio Ferreira, "Quantum effects in expanding universes"](#)
- 28 Mar [Juraj Klarić, "IFIC Seminar: Mapping the parameter space of low-scale leptogenesis"](#)
- 21 Mar [Luciano Abreu, "IFIC Seminar: Exotic hadrons in heavy ion collisions"](#)
- 14 Mar [Alberto Usón, "#Student Seminar: The NEXT experiment: in search of neutrinoless double beta decay"](#)



# 5 Seminars organized

- 13 Mar [Augusto Martinez Alves, "IFIC Experimental Seminar: Metasurfaces as light concentrators for noble elements detectors"](#)
- 09 Mar [Silvia Pla, "How can quantum tunnelling induce a cosmological bounce?"](#)
- 07 Mar [Marco Gorghetto, "HiDDeN webinar: Post-inflationary axions: gravitational waves, targets for haloscopes, and substructure"](#)
- 07 Mar [Peera Simakachorn, "IFIC Seminar: Charting cosmological history and new particle physics with primordial gravitational waves"](#)
- 02 Mar [Student Seminars: Astronomy and Astrophysics](#)
- 28 Feb [Aritra Gupta, "IFIC Seminar: Seesaw determination of dark matter relic density"](#)
- 23 Feb [Alexandre Salas Bernardez, "Topical Seminar: Distinguishing Electroweak EFTs through multi-Higgs measurements"](#)
- 22 Feb [Ruchika Kaushik, "Topical Seminar: "Investigating cosmological tensions in low and high redshift observational data""](#)
- 21 Feb [Mikhail Mikhasenko, "IFIC seminar: Exotic hadrons and heavy-flavor nuclei"](#)
- 14 Feb [Otón Vázquez Doce, "IFIC seminar: Precise tests of the hadron-hadron strong interaction via femtoscopy"](#)
- 13 Feb [Justo Martin-Albo, "IFIC Experimental Seminar: The Deep Underground Neutrino Experiment \(DUNE\)"](#)
- 07 Feb [Carlos Tamarit, "IFIC Seminar: The limits of the strong CP problem"](#)
- 01 Feb [Jorge Roser Martínez, "#StudentSeminar: Image reconstruction with gamma-rays"](#)
- 31 Jan [Isabel García García, "HiDDeN webinar: Reflections on Bubble Walls"](#)
- 24 Jan [Pablo Martínez-Miravé, "#StudentSeminar: Solar neutrinos: Shedding light on neutrino properties"](#)
- 17 Jan [Angel Gómez Nicolás, "IFIC seminar: Effective theories and the QCD phase diagram"](#)

# 6 PhD Theses 2023

## THEORETICAL PHYSICS

- *$b \rightarrow c\tau\nu\bar{\tau}$  semileptonic decays: visible distributions and tests of lepton flavour universality*  
Neus Penalva Martínez  
Advisors: Eliecer Hernández Gajate and Juan M. Nieves Pamplona  
December 12, University of Valencia  
TESEO: [2480997](#)
- *Boson stars, baby universes and wormholes in a modified gravity scenario*  
Andreu Masó Ferrando  
Advisors: Gonzalo Olmo Alba and Nicolás Sanchis Gual  
November 30, University of Valencia  
TESEO: [2480553](#)
- *Quantum Noise and Quantum Walks*  
Andreu Anglés Castillo  
Advisors: Armando Pérez Cañellas, María Carmen Bañuls Polo and Inés De Vega Rodrigo  
November 10, University of Valencia  
TESEO: [2472543](#)
- *Precision measurements with the LHC and low-energy experiments: a model independent analysis*  
Víctor Ernesto Bresó Pla  
Advisor: Martín González Alonso  
November 9, University of Valencia  
TESEO: [2479374](#)
- *Neutrino cosmology and the baryon asymmetry*  
Stefan Sandner  
Advisors: Nuria Rius Dionis and Jacobo López Pavón  
October 27, University of Valencia  
TESEO: [2467821](#)
- *Neutrino Masses and Lepton Flavor Physics Beyond the Standard Model*  
Pablo Escribano Valiente  
Advisor: Avelino Vicente Montesinos  
September 29, University of Valencia  
TESEO: [2469552](#)
- *Neutrino properties from the laboratory and the cosmos*  
Pablo Martínez Miravé  
Advisor: Mariam Tórtola Baixauli  
September 19, University of Valencia  
TESEO: [2464260](#)
- *Quantum effects, anomalies and renormalization in Electrodynamics, Cosmology and Black holes*  
Pau Beltrán Palau  
Advisors: José Navarro Salas and Adrián del Río Vega  
July 5, University of Valencia  
TESEO: [2446659](#)
- *Gravedad métrico-afín y escenarios asociados: rotación, termodinámica, holografía y campos de materia*

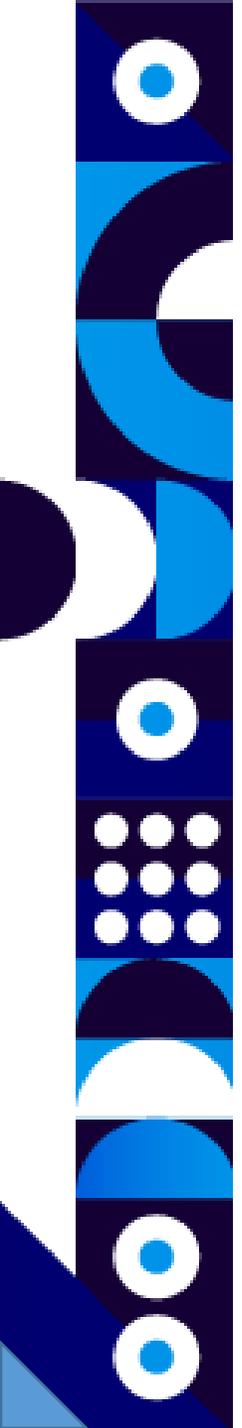
Gerardo Mora Pérez  
Advisors: Diego Rubiera García and Gonzalo Olmo Alba  
May 9, University of Valencia  
TESEO: [2401344](#)

- *From a causal representation of multiloop scattering amplitudes to quantum computing in the Loop-Tree Duality*  
Norma Selomit Ramírez Uribe  
Advisors: Germán Rodrigo García, Roger Hernández and Germán Sborlini  
April 21, University of Valencia  
TESEO: [2393979](#)
- *On the mathematical properties of multi-loop scattering amplitudes through the Loop-Tree Duality*  
José de Jesús Aguilera Verdugo  
Advisors: Germán Rodrigo García, Roger Hernández and Germán Sborlini  
April 19, University of Valencia  
TESEO: [2275239](#)
- *New physics searches from cosmic-ray air-showers*  
Víctor M. Muñoz Alborno  
Advisors: Pilar Hernández Gamazo and Pilar Coloma Escribano  
March 8, University of Valencia  
TESEO: [2380959](#)

- *Pion Photo- and Electroproduction on Nucleons in Relativistic Chiral Perturbation Theory*  
Gustavo Hazel Guerrero Navarro  
Advisors: Manuel Vicente Vacas and Luis Álvarez Ruso  
TESEO: [2313588](#)

## EXPERIMENTAL PHYSICS

- *Triggering new discoveries: development of advanced HLT1 algorithms for detection of long-lived particles at LHCb*  
Brij Kishor Jashal  
Advisor: María Aránzazu Oyanguren Campos  
November 7, University of Valencia  
TESEO: [2478729](#)
- *Joint analysis of neutrino oscillations using data from T2K and reactor experiments*  
Maria Antonova  
Advisors: Anselmo Cervera Villanueva and Pau Novella Garijo  
October 16, University of Valencia  
TESEO: [2458014](#)
- *Search for associated production of a Higgs boson and a single top quark in the multi-lepton final state with ATLAS*  
Jesús Guerrero Rojas  
Advisors: Susana Cabrera Urbán and



# 6 PhD Theses 2023

- Carlos Escobar Ibáñez  
September 15, University of Valencia  
TESEO: [2466216](#)
- Probing the top quark couplings within the ATLAS detector and EFT global fits*  
Marcos Miralles López  
Advisor: María Moreno Llácer  
July 25, University of Valencia  
TESEO: [2456424](#)
- K<sup>+</sup> Signatures in the ProtoDUNE-SP Detector at CERN*  
Miguel Ángel García Peris  
Advisor: Anselmo Cervera Villanueva  
July 24, University of Valencia  
TESEO: [2455344](#)
- Improving Image Quality in a multi-plane Compton Telescope for Hadron Therapy Monitoring*  
Jorge Roser Martínez  
Advisors: Gabriela Llosá Liácer and José Francisco Oliver Guillén  
July 10, University of Valencia  
TESEO: [2454789](#)
- Measurement of the Xe-136 two-neutrino double beta decay half-life with the NEXT-White detector*  
Alberto Usón Andrés  
Advisors: Pau Novella Garijo and Michel Sorel  
June 26, University of Valencia  
TESEO: [2453028](#)
- Nuevas medidas de la emisión de neutrones en la desintegración beta de <sup>85</sup>Ge, <sup>85,86</sup>As, <sup>91</sup>Br, <sup>135</sup>Sb, <sup>137,138</sup>Te y <sup>138,139,140</sup>I*  
Jorge Agramunt Ros  
Advisor: José Luis Taín Enríquez  
May 9, University of Valencia  
TESEO: [2398719](#)
- Development of the first PETALO prototype for medical imaging and SiPM studies for neutrino physics*  
Carmen Romo Luque  
Advisor: Paola Ferrario  
March 31, University of Valencia  
TESEO: [2404362](#)
- Performance Improvements of EventIndex Distributed System at CERN*  
Álvaro Fernández Casaní  
Advisors: Juan M. Orduña Huertas and Santiago González de la Hoz  
March 7, University of Valencia  
TESEO: [2394519](#)
- Search for Neutrino Non-Standard Interactions with the KM3NeT/ORCA 6 lines detector*  
Jerzy Mańczak  
Advisors: Juan de Dios Zornoza Gómez and Juan José Hernández Rey  
January 13, University of Valencia  
TESEO: [2295759](#)

# 7 Masters 2023

## THEORETICAL PHYSICS

- *Cálculo de correcciones de QED al proceso de Drell-Yan relevantes para la determinación de la masa del bosón  $W$*   
Fernando Álvarez Clavera  
Advisor: Leandro Javier Cieri
- *Regresión simbólica para obtener leyes de comportamiento con la ayuda de deep learning*  
Himar Bravo Pérez  
Advisor: Verónica Sanz González
- *Examining the behaviour of quantum scalar fields inside black holes*  
Pablo María Chisvert Ramírez  
Advisor: Adrián del Rio Vega
- *Strong CP Problem and the Quantum Mechanic Rotor*  
Sergio De La Cruz Alzaga  
Advisor: Alberto Ramos Martínez
- *Dark matter in minimal non-minimal universal extra dimensions*  
Ignacio José Juan Bordera  
Advisors: Andrea Donini, Roberto Ruíz de Austri Bazan
- *Revisión de mecanismos electrodébiles capaces de producir la homoquiralidad molecular*  
Daniel Martínez Gil  
Advisors: Gonzalo Olmo Alba, Salvador Miret Artés (IFT), Pedro Bargeño de Retes (UA)
- *Characterizing the inflationary and post-inflationary eras of our universe*  
Arturo Salvador Núñez Anaya  
Francisco Torrentí Salom
- *Trinification: lepton number and neutrino masses*  
Javier Pérez Soler  
Advisors: Avelino Vicente Montesinos, Renato Fonseca
- *The last missing ingredient of the signal-background interference in the  $H \rightarrow \gamma\gamma$  channel at the LHC*  
Francisco Manuel Sánchez Rodríguez  
Advisor: Leandro Javier Cieri
- *Aspects of the phenomenology of a  $Z'$  boson: LHC and dark matter detection*  
Adrian Terrones Aragon  
Advisor: Víctor Martín Lozano

## NUCLEAR AND PARTICLES PHYSICS

- *Clasificación y búsqueda de violación de sabor leptónico para desintegraciones del bosón de Higgs en los canales  $e\tau$  y  $\mu\tau$  con datos de ATLAS del LHC*  
Alvaro Anreus Valero  
Advisor: Luca Fiorini
- *Eficiencia de detección de luz ultravioleta profunda en el experimento DUNE*  
Clara Carrion Martinez  
Advisors: Anselmo Cervera, Justo Martín-Albo Simón
- *Hybrid detector of gamma-rays and ultrasound for biopsy guidance in breast cancer*  
José Manuel Escalante Castro  
Advisor: Luis Caballero Ontanaya
- *Estudio de la interacción de radiación con nanopartículas de oro en Geant4 para mejorar la eficiencia de las terapias contra cáncer basadas en protones*  
Brandon Santiago Guallazaca Gonzalez  
Advisors: Daniel Esperante Pereira, Nuria Fuster Martínez
- *Sistema de monitorización de temperaturas del experimento DUNE basado en la tecnología de redes de Bragg en fibra*  
María Lorenzo Domínguez  
Advisors: Nadia Yahlali Haddou, Anselmo Cervera Villanueva
- *Desarrollo de cámaras Compton para aplicaciones médicas*  
Paula Lozano Durán  
Advisor: Gabriela Llosá Llácer
- *Analysis of the geolocalization of a haloscope system for the detection of dark matter axions in the microwave frequency region*  
José Reina Valero  
Advisors: Benito Gimeno Martínez, Carlos Peña Garay
- *Development of nuclear instrumentation for studies of climate change effects on marine ecosystems*  
Lucía Sánchez Blázquez  
Advisors: Enrique Nácher González, Javier Balibrea Correa
- *Study of the isomeric states in the  $100\text{Sn}$  region using the DTAS spectrometer*  
Víctor Vegas Luque  
Advisor: Alejandro Algora, José Antonio Victoria Fernández

# 8 Grants

## NATIONAL PROJECTS

- Monitorización y dosimetría en terapia hadrónica  
Ref. PID2019-110657RB-100 Ayudas Extraordinarias 2023AEP127  
PI: Gabriela Llosá Llácer  
10,124 € (Jun 2023 – Nov 2023)
- Nuclear Structure Astrophysics and Applications (NUSTASAP-IFIC)  
Ref. PID2019-104714GB-C21 Ayudas Extraordinarias 2023AEP128  
PI: Enrique Nacher González  
41,123 € (Jun 2023 – Dec 2023)
- Participación española en estructuras de investigación en física de partículas, astropartículas y nuclear  
Ref. RED2022-134204-E  
PI: Antonio Pich Zardoya  
60,000 € (Jan 2023 – Dec 2024)
- Evaluación del potencial de BabyLAXO para detectar ondas gravitacionales y candidatos a materia oscura más allá del QCD axión  
Ref. PID2022-137268NA-C55  
PI: Camilo Alfredo García Cely  
47,625 € (Sep 2023 – Aug 2026)
- Imagen médica para mejora de diagnóstico y tratamientos  
Ref. PID2022-1432460B-I00  
PI: Gabriela Llosa Llácer  
175,000 € (Sep 2023 – Aug 2026)

- Investigando el entrelazamiento cuántico a altas energías con el detector ATLAS en el LHC  
Ref. CNS2022-135718  
PI: Carlos Escobar Ibáñez  
178,110 € (Sep 2023 – Aug 2025)
- La constante de acoplo fuerte para física de alta precisión  
Ref. CNS2022-136005  
PI: Alberto Ramos Martínez  
198,196 € (Sep 2023 – Aug 2025)
- Asentando la búsqueda de sectores oscuros en el experimento NA64 del CERN usando un haz de muones  
Ref. CNS2022-135850  
PI: Laura Molina Bueno  
198,702 € (Sep 2023 – Aug 2025)
- Estudio de QED en regímenes extremos en LUXE  
Ref. CNS2022-135420  
PI: Adrián Irlés Quiles  
199,285 € (Sep 2023 – Aug 2025)
- Mejora de la detección de fotones en un detector NEXT en la escala de la tonelada  
Ref. CNS2022-135619  
PI: Justo Martín-Albo Simón  
199,406 € (Sep 2023 – Aug 2025)
- I+D en demostradores DMAPS de gran superficie para futuros colisionadores  
Ref. CNS2022-135606

PI: Carlos Mariñas Pardo  
199,527 € (Sep 2023 – Aug 2025)

• Nuclear structure, Astrophysics and Knowledge Transfer IFIC  
Ref. PID2022-138297NB-C21  
PI: Cesar Domingo, Ariel Tarifeño  
470,250 € (Sep 2023 – Aug 2026)

• Tier-2 Federado Español de ATLAS (Centro IFIC) para afrontar el reto del almacenamiento, gestión, procesado y análisis del Big Data del LHC (ES-ATLAS-T2)  
Ref. PID2022-136323OB-C21  
PI: Santiago G.de la Hoz, José Enrique García  
729,250 € (Sep 2023 – Aug 2026)

• Hacia el Nuevo Modelo Estándar Oscuro y Unificado  
Ref. CNS-2022-135592  
PI: Juan Andrés Herrero García  
199,283 € (Sep 2023 – Aug 2025)

• Fenomenología Avanzada en la era del LHC  
Ref. CNS-2022-136165  
PI: Francisco Campanario Pallas  
199,408 € (Sep 2023 – Aug 2025)

• Propiedades fundamentales de hadrones exóticos  
Ref. CNS-2022-136146  
PI: Raquel Molina Peralta  
199,408 € (Sep 2023 – Aug 2025)

• Neutrinos: desvelando una escala en Nueva Física  
Ref. CNS-2022-136013  
PI: Jacobo López Pavón  
199,417 € (Sep 2023 – Aug 2025)

• Llevando al límite lo que el LHC es capaz de hacer  
Ref. CNS-2022-135688  
PI: Verónica Sanz González  
199,611 € (Sep 2023 – Aug 2025)

• Neutrones, núcleos y colisionadores (NENUCO)  
Ref. CNS2022-135595  
PI: Martín González Alonso  
199,363 € (Sep 2023 – Aug 2025)

• Retando la física y la tecnología con el detector mejorado LHCb del CERN  
Ref. PID2022-139842NB-C22  
PI: Fernando Martínez, Arantza Oyanguren  
474,125 € (Sep 2023 – Aug 2026)

• The upgraded LHCb Detector at CERN - IFIC  
Ref. PCI2023-146012-2  
PI: Fernando Martínez Vidal  
84,000 € (Sep 2023 – Aug 2026)

• Stochastic Gravitational wave backgrounds: From first principles calculation to detection and implications for fundamental physics  
Ref. EUR2022-134028  
PI: Daniel Garcia Figueroa  
89,646 € (Dec 2022 – Nov 2023)

• ATLAS participación in the LCH IFIC  
Ref. PCI2022-135002-2  
PI: Salvador Marti García  
102,000 € (Jan 2022 – Dec 2024)

• The ITK Upgrade of ATLAS IFIC  
Ref. PCI2022-135087-2  
PI: Carlos Lacasta Llácer  
765,000 € (Jan 2022 – Dec 2024)



# 8 Grants

• Proton Range and Imaging Device for protontherapy  
Ref. PDC2022-133382-100  
PI: Enrique Nacher González  
149,500 € (Dec 2022 – Nov 2024)

• Telescopio para CT de protones ha Hadron Terapia  
Ref. PDC2022-133605-100  
PI: Carlos Lacasta Llácer  
115,000 € (Dec 2022 – Nov 2024)

• LHC y la fábrica de Higgs - física y aspectos tecnológicos  
Ref. PID2021-122134NB-C21  
PI: Vasiliki Mitsou, Marcel Vos  
446,490 € (Sep 2022 – Aug 2025)

• Búsquedas de sectores oscuros con el experimento NA64 en el CERN  
Ref. PID2021-123955NA-100  
PI: Laura Molina Bueno  
102,850 € (Sep 2022 – Aug 2025)

• Telescopios de neutrinos para física fundamental y astronomía multimensajero  
Ref. PID2021-124591NB-C41  
PI: Juan de Dios Zornoza, Juan J. Hernández  
919,600 € (Sep 2022 – Aug 2025)

• Contribución a la operación del experimento ATLAS y su programa de física durante el Run3 del LHC  
Ref. PID2021-124912NB-100  
PI: Salvador Marti Garcia, Luca Fiorini  
592,900 € (Sep 2022 – Aug 2025)

• Upgrade del detector ATLAS: Electrónica del Tile Calorimeter, Trigger y Explotación del Programa de Física  
Ref. PID2021-125069OB-100  
PI: Arantxa Ruiz, José Alberto Valero  
699,380 € (Sep 2022 – Aug 2025)

• Explotación científica del detector NEXT-100 y R&D para el detector NEXT-HD  
Ref. PID2021-125475NB-C52  
PI: Pau Novella, Justo Martín-Albo  
505,780 € (Sep 2022 – Aug 2025)

• Outlining sensors for future experiments in large radiation environments and the ltk strip upgrade of ATLAS  
Ref. PID2021-1263270B-C21  
PI: Carlos Lacasta, Carlos Mariñas  
605,000 € (Sep 2022 – Aug 2025)

• Restoration Ecology and Artificial Intelligence (RESECARIN)  
Ref. TED2021-130852B-100  
PI: Luca Fiorini, Veronica Sanz  
575,000 € (Sep 2022 – Aug 2025)

• Física Nuclear y Hadrónica a Energías Intermedias  
Ref. PID2020-112777GB-100  
PI: Juan Miguel Nieves, Luis Álvarez  
193,600 € (Sep 2021 – Aug 2024)

• Predicción de amenazas asociadas a corrientes inducidas geomagnéticamente en las infraestructuras críticas españolas  
Ref. PID2020-113135RB-C33  
PI: Carlos Escobar Ibáñez  
54,450 € (Sep 2021 – Aug 2024)

• Astropartículas y Física de Altas Energías  
Ref. PID2020-113775GB-100  
PI: Martin Hirsch, Maria Amparo Tórtola  
176,660 € (Sep 2021 – Aug 2024)

• Estudios de Estructura Nuclear y Desarrollos Instrumentales para AGATA un multidetector de trazado para las instalaciones de haces estables y radioactivos en Europa  
Ref. PID2020-118265GB-C42  
PI: Andrés Gadea  
359,249 € (Sep 2021 – Aug 2024)

• Cámara Compton para verificación de rango en hadronterapia  
Ref. PDC2021-121536-C21  
PI: Cesar Domingo Pardo  
74,7450 € (Dec 2021 – Nov 2023)

• Partículas elementales: el Modelo Estándar y sus extensiones  
Ref. PID2020-113334GB-I00  
PI: Oscar Manuel Vives, Sergio Palomares  
279,631 € (Sep 2021 – Aug 2024)

• Física de sabor, del bosón de Higgs y de las interacciones fuertes en el LHC y la frontera de intensidad  
Ref. PID2020-114473GB-I00  
PI: Antonio Pich, Germán Rodrigo  
279,510 € (Sep 2021 – Aug 2024)

• Sabor y Origen de la Materia  
Ref. PID2020-113644GB-I00  
PI: Pilar Hernández, Olga Mena  
290,400 € (Sep 2021 – Aug 2024)

• Campos y Gravedad  
Ref. PID2020-116567GB-C21

PI: Gonzalo Olmo Alba, Alessandro Fabri  
96,800 € (Sep 2021 – Aug 2024)

• Valorización de nuevos detectores para imagen médica  
Ref. PDC2021-121839-100  
PI: Gabriela Llosá Llácer  
115,000 € (Dec 2021 – Nov 2023)

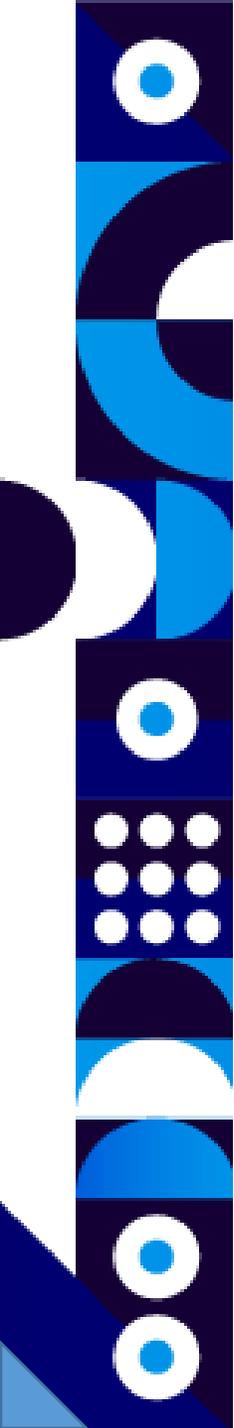
• Nuclear Structure Astrophysics and Applications (NUSTASAP-IFIC)  
Ref. PID2019-104714GB-C21  
PIs: Enrique Nacher Arándiga, Alejandro Algora  
506,990 € (Jun 2020 – May 2023)

• Hacia un genuino TIER-2 (centro IFIC) federado español de ATLAS para afrontar el reto de la gestión y procesado del Big Data del LHC (FASEII)  
Ref. PID2019-104301RB-C21  
PI: Santiago González de la Hoz, José Salt  
603,790 € (Jun 2020 – May 2023)

• Monitorización y dosimetría en terapia hadronica  
Ref. PID2019-110657RB-I00  
PI: Gabriela Llosá Llácer  
98,010 € (Jun 2020 – May 2023)

• Contribución del IFIC al programa científico del experimento de neutrinos DUNE  
Ref. PID2019-104676GB-C33  
PI: Anselmo Cervera Villanueva  
356,950 € (Jun 2020 – May 2023)

• Modelos de hadrones, interacciones fundamentales y física nuclear  
Ref. PID2019-105439GB-C21  
PI: Pedro González Marhuenda  
60,500 € (Jun 2020 – May 2023)



# 8 Grants

- Retos de Física y Tecnológicos en el IFIC con el Experimento LHCb del CERN  
Ref. PID2019-106448GB-C33  
PI: Arantza Oyanguren, Fernando Martínez  
360,580 € (Jun 2020 – May 2023)

## EUROPEAN PROJECTS

- Contribución del CSIC al proyecto ESFRI KM3NeT 2.0: Impulsando la investigación en astrofísica y física fundamental  
Ref. INFRA23013  
PI: Francisco Salesa  
99,638 € (Jun 2023 – May 2025)

- EAJADE: Europe-America-Japan Accelerator Development and Exchange Programme  
Ref. HORIZON-MSCA-2021-SE-01 Project: 101086276  
PI: Juan Fuster (Nuria Fuster)  
119,600 € (Mar 2023 – Feb 2027)

- SENSE: Search for new physics and technological advancements from neutrino experiments at the high intensity frontier. A cooperative Europe - United States - Brazil - Russia effort  
Ref. HORIZON-MSCA-2021-SE-01 Project: 101081478  
PI: Michel Sorel  
128,800 € (Jan 2023 – Dec 2026)

- "Advanced imaging system for Medical Applications" (AMA)  
Ref. ERC-2023-POC Project: 101137646 – AMA  
PI: César Domingo Pardo  
136,000 € (Nov 2023 – May 2025)

- COLLINEAR-FRACTURE (Towards loop splitting amplitudes and collinear factorisation breaking)  
Ref. HORIZON-MSCA-2022-PF-01 – 101108573  
PI: Germán Rodrigo (Prasanna Dhani)  
181,153 € (May 2023 – Apr 2025)

- InnDIH - Valencia Region Digital Innovation Hub: Proposal ID 101083002  
Ref. 101083002  
PI: José Enrique García Navarro  
189,497 € (Jan 2023 – Dec 2025)

- KM3NET-INFRADEV2 Towards full implementation of the KM3NeT Research Infrastructure  
Ref. 101079679  
PI: Francisco Salesa  
225,000 € (Jan 2023 – Dec 2025)

- Cartan geometry, Lie and representation theory, Integrable Systems, quantum Groups and quantum computing towards the understanding of the geometry of deep Learning and its Applications- (CaLIGOLA)  
Ref. HORIZON-MSCA-2021-SE-01 –

- 101086123  
PI: M<sup>a</sup> Antonia Lledó Barrena  
170,200 € (Jan 2023 – Dec 2026)

- A charming decade: using colliders to probe the charm sector of the Standard Model and Beyond  
H2020-MSCA-IF-2020/101031558-charming-DecaDe  
Fellow: Luiz Vale  
PI: Antonio Pich Zardoya  
160,932 € (Nov 2021 – Oct 2023)

- UNOS: Unifying Neutrino Observatories Searches  
H2020-MSCA-IF-2020/101025085-UNOS  
Fellow: Alfonso Andrés García Soto  
PI: Juan de Dios Zornoza Gómez  
204,415 € (May 2021 – Sep 2023)

- HIDDEN. Hunting invisibles: Dark sectors, Dark Matter and Neutrinos  
H2020-MSCA-ITN-2019/860881-HIDDEN  
PI: Pilar Hernández Gamazo  
382,175 € (Jan 2020 – Sep 2024)

- SANDA. Supplying Accurate Nuclear Data for energy and non-energy Application  
NFRP-2018 Ref. 847552  
PI: Alejandro Algora  
48,999 € (Sep 2019 – Aug 2023)

- STRONG-H2020. The strong interaction at the frontier of knowledge:- fundamental research and applications  
H2020-INFRAIA-2018-1 Ref. 824093  
PI: Santiago Noguera Puchol  
81,500 € (Jun 2019 – May 2023)

- A positron emission tomography apparatus based on liquid xenon with time of flight applications - PETALO  
ERC-2017-STG Ref. 757829  
PI: Anselmo Cervera Villanueva  
224,856 € (July 2018 – June 2023)

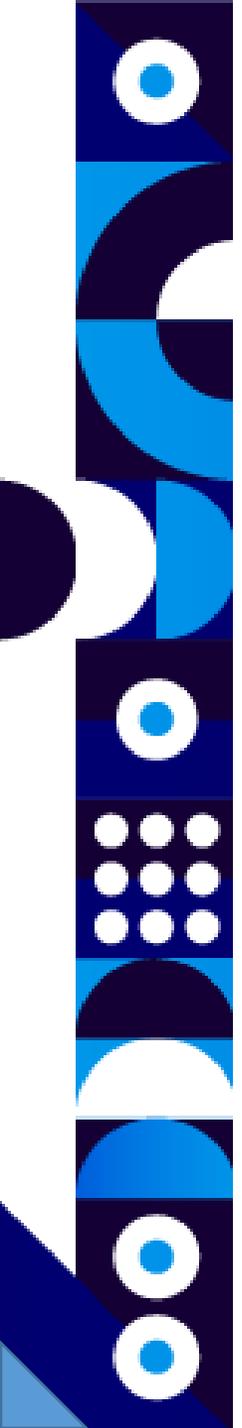
- A positron emission tomography apparatus based on liquid xenon with time of flight applications – PETALO  
ERC-2017-STG Ref.757829  
PI: Pilar Hernández Gamazo  
306,250 € (July 2018 – June 2023)

## REGIONAL PROJECTS

- Theoretical approaches in model building and phenomenology of physics beyond the Standard Model in connection with neutrino physics  
Ref. CIDEIG/2022/16  
PI: Chandan Hati  
285,000 € (Jul 2023 – Jul 2027)

- Exploring the universe with large scale structure observations and cosmological simulations  
Ref. CIDEIG/2022/17  
PI: Deng Wang  
269,273 € (Jul 2023 – Jul 2027)

- Beta decay studies for fundamental physics and applications  
Ref. CIPROM/2022/9  
PI: Alejandro Algora  
349,217 € (Jan 2023 – Dec 2025)



# 8 Grants

• Search for the sources of high-energy cosmic rays with the KM3NeT neutrino telescope in the era of Multi-messenger astronomy

Ref. CIDEAGENT/2018/034

PI: Francisco Salesa Greus  
169,807 € (Jan 2023 – Dec 2024)

• Dark matter and neutrinos as gateways to new physics (D'AMAGAT)

Ref. CIDEXG/2022/20

PI: Valentina De Romeri  
541,545 € (Mar 2023 – Feb 2027)

• Desarrollo de instrumentación nuclear avanzada para AGATA y sus detectores complementarios. Aplicaciones en Física Médica e Imagen Compton

Ref. CIPROM/2022/54

PI: Andrés Gadea Raga  
599,460 € (Jan 2023 – Dec 2026)

• Explotación de la física del Run-3 del LHC con el detector ATLAS, su actualización para HL-LHC y aplicaciones de las tecnologías desarrolladas a los retos de la sociedad

Ref. CIPROM/2022/70

PI: Carmen García, Susana Cabrera  
600,000 € (Jan 2023 – Dec 2026)

• Elucidating the nature of the neutrino: R&D towards tonne scale detectors for neutrinoless double beta decay searches

Ref. CISEJI/2023/27

PI: Neus López March  
317,065 € (Jan 2023 – Dec 2026)

• The present and future of precision physics

Ref. CIDEAGENT/2018/014

PI: Martín González Alonso  
170,000 € (Jan 2023 – Dec 2024)

• Neutrinos: Hunting a new Physics Scale

Ref. CIDEAGENT/2018/019

PI: Jacobo López Pavón  
170,000 € (Jan 2023 – Dec 2024)

• Sabor y Origen de la Materia (SOM)

Ref. CIPROM/2022/69

PI: Nuria Rius, Andrea Donini  
596,960 € (Jan 2023 – Dec 2026)

• The Standard model and beyond in the quantum information era

Ref. CIPROM/2022/66

PI: Arcadi Santamaria, Armando Pérez  
600,000 € (Jan 2023 – Dec 2026)

• Retos experimentales y teóricos en la frontera de la intensidad: Sabor y Nueva Física (RETIS)

Ref. CIPROM/2022/36

PI: Francisco J. Botella, Fernando Martínez  
600,000 € (Jan 2023 – Dec 2026)

• Potenciación de la UCIE del IFIC

Ref. INNVA2/2023/8

PI: José Enrique García Navarro, Nuria Rius Dionis

499,900 € (Jan 2023 – Dec 2025)

• Computación avanzada para el procesado intensivo de Big Data en ATLAS

Ref. ASFAE/2022/006

PI: Miguel Villaplana, Emma Torró  
299,863 € (Apr 2022 – Jun 2025)

• Detector de trazas de ATLAS para el HL-LHC

Ref. ASFAE/2022/007

PI: Carlos Escobar, Carmen Garcia  
299,920 € (Apr 2022 – Jun 2025)

• Upgrade del detector ATLAS: Electrónica del Tile Calorimeter y Explotación del Programa de Física

Ref. ASFAE/2022/008

PI: Luca Fiorini, Arantxa Ruiz  
299,693 € (Apr 2022 – Jun 2025)

• Algoritmos cuánticos en fenomenología de partículas elementales

Ref. ASFAE/2022/009

PI: Germán Rodrigo, Martín González  
123,219 € (Apr 2022 – Jun 2025)

• Operación del experimento ATLAS durante el RUN 3 del LHC y explotación de sus datos para el estudio del bosón de Higgs y el quark top

Ref. ASFAE/2022/010

PI: Joaquín Poveda, María Moreno  
212,469 € (Apr 2022 – Jun 2025)

• Tecnologías de RF para monitores de haz en aceleradores y para detectores de axiones de materia oscura

Ref. ASFAE/2022/013

PI: Daniel Esperante, Nuria Fuster  
284,050 € (Apr 2022 – Jun 2025)

• Desarrollo y construcción de un demostrador de un detector de alta granularidad basado en tecnologías de silicio para futuras fábricas de Higgs y Top

Ref. ASFAE/2022/015

PI: Adrián Irlés, Marcel Vos  
284,979 € (Apr 2022 – Jun 2025)

• Sensores Monolíticos para búsqueda de Nueva Física

Ref. ASFAE/2022/016

PI: Carlos Mariñas, Laura Molina  
203,719 € (Apr 2022 – Jun 2025)

• Imagen Compton para terapia con radionúclidos (ICOR)

Ref. ASFAE/2022/019

PI: Gabriela Llosá, Irene Torres  
299,920 € (Apr 2022 – Jun 2025)

• Ondas Gravitacionales, Axiones y Materia Oscura, Lattice e Inteligencia Artificial

Ref. ASFAE/2022/020

PI: Alberto Ramos, Olga Mena  
299,843 € (Apr 2022 – Jun 2025)

• Modeling neutrino interactions with matter for current and futures experiments

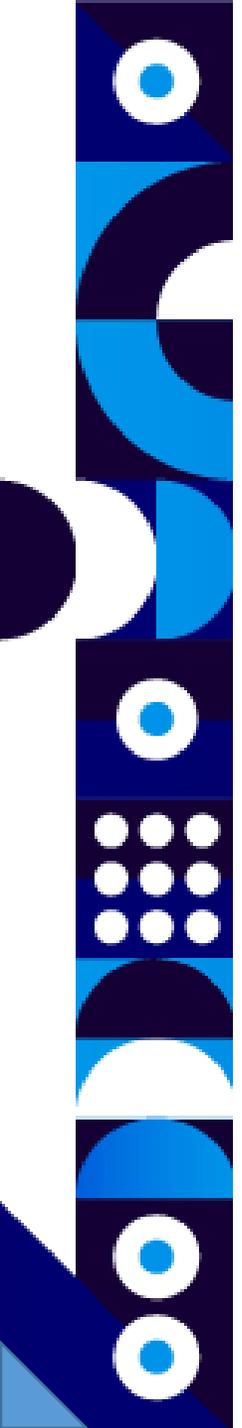
Ref. ASFAE/2022/022

PI: Luis Álvarez Ruso  
106,877 € (Apr 2022 – Jun 2025)

• Adquisición y sincronización avanzada para Astrofísica

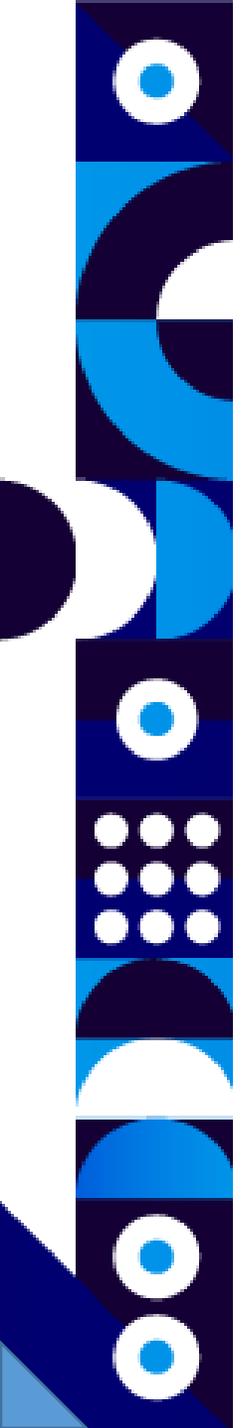
Ref. ASFAE/2022/023

PI: Juan de Dios Zornoza, Rebeca Gozzini  
300,000 € (Apr 2022 – Jun 2025)



# 8 Grants

- Artificial Environment for ML and Innovation in Scientific Advanced Computing  
Ref. ASFAE/2022/024  
PI: José Enrique García, Bryan Zaldívar  
299,000 € (Apr 2022 – Jun 2025)
- Detectores complementarios modulares de nueva generación  
Ref. ASFAE/2022/027  
PI: Alejandro Algora, Javier Balibrea  
299,587 € (Apr 2022 – Jun 2025)
- Creation of a multipurpose laboratory at IFIC for the development of cryogenically-cooled gas and liquid noble element detectors  
Ref. ASFAE/2022/028  
PI: Anselmo Cervera, Neus López  
299,000 € (Apr 2022 – Jun 2025)
- Development of state-of-the-art light detection systems for the DUNE and NEXT experiments  
Ref. ASFAE/2022/029  
PI: Nadia Yahladi, Justo Martín-Albo  
299,000 € (Apr 2022 – Jun 2025)
- Retos tecnológicos para el descubrimiento con el detector LHCb mejorado del CERN  
Ref. ASFAE/2022/030  
PI: Fernando Martínez, Arantza Oyanguren  
273,102 € (Apr 2022 – Jun 2025)
- Instrumentación avanzada para la experimentación con GRIT y AGATA  
Ref. ASFAE/2022/031  
PI: Andrés Gadea, Vicente González  
284,596 € (Apr 2022 – Jun 2025)
- Coordinación Proyectos ASFAE  
Ref. ASFAE/COORD  
PI: Carlos Lacasta Llácer  
300,000 € (Apr 2022 – Jun 2025)
- Desarrollo de aceleradores lineales de alto gradiente y nuevas técnicas para su aplicación en radioterapia  
Ref. CDEIGENT/2021/012  
PI: Nuria Fuster Martínez  
285,000 € (Apr 2022 – Dec 2025)
- Información cuántica y metrología  
Ref. CDEIGENT/2021/014  
PI: Manuel Gessner  
285,000 € (Jul 2022 – Jul 2026)
- Estudio del autoacoplamiento del bosón de Higgs en el experimento ATLAS del LHC  
Ref. CIAICO/2021/154  
PI: Arantxa Ruiz Martínez  
90,000 € (Jan 2022 – Dec 2024)
- Dark and Shiny Dresses around Black Holes  
Ref. CIDEAGENT/2021/017  
PI: Daniele Gaggero  
539,765 € (Jan 2022 – Dec 2025)
- Search for new physics signatures and measurement of fundamental neutrino properties with the KM3NeT telescope  
Ref. CIDEAGENT/2021/023  
PI: Sara Rebecca Gozzini  
556,000 € (Jan 2022 – Dec 2025)
- Dark Bosons and Dark Matter  
Ref. CIDEAGENT/2021/025  
PI: Christian Gross  
481,706 € (Jul 2022 – Jul 2026)
- Searching for new physics in the flavour sector with precision hadronic physics  
Ref. CIDEAGENT/2021/037  
PI: Emilie Passemar  
610,000 € (Jul 2022 – Jul 2026)
- Dark Matter capture in Celestial bodies  
Ref. CIDEIG/2022/22  
PI: Aritra Gupta  
284,902 € (Dec 2022 – Nov 2026)
- Astroparticle and neutrino physics: from Cosmology to the LHC (AstroParNu)  
Ref. CIPROM/2021/054  
PI: Mariam Tórtola, Gabriela Barenboim  
600,000 € (Jan 2022 – Dec 2025)
- Innovación y desarrollo en la mejora y personalización de los tratamientos de radioterapia convencional y protonterapia.  
Ref. CIPROM/2021/064  
PI: Javier Vijande Asenjo  
412,522 € (Jan 2022 – Dec 2025)
- The Quest for New Physics (QNe2Phys). High precision, direct searches and technology development  
Ref. CIPROM/2021/073  
PI: Juan Antonio Fuster, Vasiliki Mitsou  
600,000 € (Jan 2022 – Dec 2025)
- Total Absorption spectroscopy Technique Applied to Key Isotopes in r-Process nucleosynthesis of trans-bismuth elements (TATAKI-Pro)  
Ref. CISEJI/2022/25  
PI: Ana Isabel Morales López  
320,000 € (Jan 2022 – Dec 2025)
- Radiotrazadores para el estudio de ecosistemas marinos y oceánicos (REMO)  
Ref. THINKINAZUL/2021/036  
PI: Enrique Nacher González  
205,324 € (Jan 2022 – Sep 2025)
- Cámara dual de visualización neutrón-gamma para protonterapia (gnvision4health)  
Ref. VALORITZA I TRANSFEREIX  
PI: Jorge Lerendegui Marco  
58,696 € (Sep 2022 – Sep 2023)
- Understanding non-perturbative phenomena in fundamental physics  
Ref. PROMETEO/2021/083  
PI: Verónica Sanz, Daniel G. Figueroa  
469,106 € (Jan 2021 – Dec 2024)
- Valorización de un Sistema de Monitorización para terapia Hadrónica (Valmont)  
Ref. INNVA1/2021/37  
PI: Gabriela Llosá Llácer  
337,926 € (Jan 2021 – Dec 2023)
- Open questions on the fundamental interactions of matter at the LHC and Intensity Frontiers  
Ref. PROMETEO/2021/071  
PI: Antonio Pich Zardoya  
475,000 € (Jan 2021 – Dec 2024)



# 8 Grants

• Física experimental de neutrinos en el IFIC  
Ref. PROMETEO/2021/087  
PI: Michel Sorel  
524,893 € (Jan 2021 – Dec 2024)

• Effective field theories in hadron and nuclear physics  
Ref. PROMETEO/2020/023  
PI: Juan M. Nieves Pamplona  
216,634 € (Jan 2020 – Dec 2023)

• Telescopios de neutrinos en el Mediterráneo  
Ref. Telescopios de neutrinos en el Mediterráneo  
PI: Juan José Hernández Rey  
250,353 € (Jan 2020 – Dec 2023)

• Aspectos clásicos y cuánticos en gravitación: agujeros negros, cosmología, ondas gravitacionales y más allá  
Ref. PROMETEO/2020/079  
PI: Gonzalo Olmo Alba  
192,160 € (Jan 2020 – Dec 2023)

• Frontiers in neutrino oscillations: precision and new phenomena  
Ref. CDEIGENT/2020/003  
PI: Francesco Capozzi  
244,667 € (Nov 2021 – Jun 2025)

• Unitary effective theories in hadron physics: new particles and new physics  
Ref. CIDEAGENT/2020/002  
PI: Miguel Albaladejo Serrano  
402,015 € (Jul 2021 – Jun 2025)

• N3LO as the New Standard for Precision Physics at the LHC  
Ref. CIDEAGENT/2020/011  
PI: Leandro Javier Cieri  
409,702 € (Jul 2021 – Jun 2025)

• Estudios de Física e I+D en detectores para futuros colisionadores de leptones  
Ref. CIDEAGENT/2020/021  
PI: Adrián Irlés Quiles  
410,000 € (Jan 2021 – Dec 2024)

• Multimessenger astronomy in the KM3NeT observatory: gravitational waves, gamma rays and cosmic neutrinos  
Ref. CIDEAGENT/2020/049  
PI: Agustín Sánchez Losa  
408,735 € (Apr 2021 – Mar 2025)

• Novel methods in Dark Matter searches with Artificial Intelligence  
Ref. CIDEAGENT/2020/055  
PI: Bryan Zaldívar Montero  
403,140 € (Jul 2021 – Jun 2025)

• Contribución al experimento ATLAS y análisis de datos I+D para futuros aceleradores y estudios de la física del quart  
Ref. CDEIGENT/2019/003  
PI: Adrián Irlés Quiles  
252,250 € (Jul 2020 – Jun 2024)

• Novel cost-effective proton range verification based on coaxial prompt gamma-ray monitoring

Ref. CDEIGENT/2019/011  
PI: Fernando Hueso González  
252,250 € (Jun 2020 – May 2024)

• Neutrino physics in the NEXT, T2K and DUNE experiments  
Ref. CDEIGENT/2019/016  
PI: Laura Molina Bueno  
229,333 € (Jun 2020 – Jun 2024)

• The strong coupling for precision physics  
Ref. CIDEAGENT/2019/040  
PI: Alberto Ramos Martínez  
381,500 € (Jul 2020 – Jun 2024)

• Física en el experimento ATLAS del LHC  
Ref. CIDEAGENT/2019/029  
PI: Carlos Escobar Ibáñez  
381,475 € (Jan 2020 – Jun 2024)

• Search for new physics in the neutrino sector with the DUNE and NEXT experiments  
Ref. CIDEAGENT/2019/049  
PI: Justo Martín-Albo Simón  
381,500 € (Jul 2020 – Jun 2024)

• Search for long-lived particles with LHC data  
Ref. CIDEAGENT/2019/023  
PI: Emma Torro Pastor  
381,475 € (Apr 2020 – Mar 2024)

• Long-lived particles (LLPs) at present and future experiments  
Ref. CIDEAGENT/2019/068  
PI: José Francisco Zurita  
338,456 € (Dec 2020 – Nov 2024)

• Effective field theories for hadron exotic states with applications in lattice QCD  
Ref. CIDEAGENT/2019/015

PI: Raquel Molina Peralta  
376,167 € (Jul 2020 – Jun 2024)

• What New Physics Lies Beyond The Standard Model  
Ref. CIDEAGENT/2019/024  
PI: Miguel Rubén Nebot Gómez  
370,410 € (Jul 2020 – Jun 2024)

• Precision jet substructure in the LHC  
Ref. CIDEAGENT/2019/027  
PI: Miguel Villaplana Pérez  
381,500 € (Jul 2020 – Jun 2024)

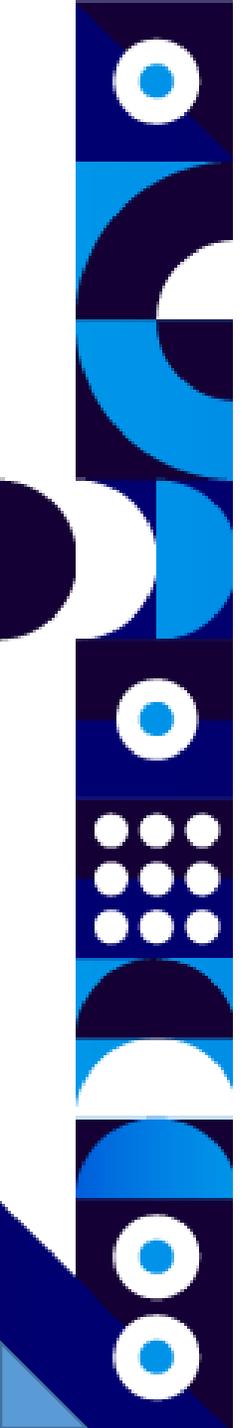
• Neutrino Masses and Dark Matter: Towards the New Standard Model  
Ref. CIDEAGENT/2020/020  
PI: Juan Andrés Herrero García  
409,999 € (Jan 2020 – Nov 2024)

## OTHER PROJECTS

• Ayuda atracción del talento RyC 2021 \_ INTRAMURAL  
Ref. 20235AT020  
PI: Justo Martín-Albo Simón  
100,000 € (May 2023 – Apr 2026)

• Técnicas innovativas para el cálculo de observables en el LHC a la precisión más alta  
Ref. ILINK22045  
PI: Javier Leandro Cieri  
22,232 € (Jan 2023 – Dec 2024)

• Dark SHOWers at present and future colliders (DASHO)  
Ref. ILINK22043  
PI: José Francisco Zurita  
24,000 € (Jan 2023 – Dec 2024)



# 8 Grants

- Lattice calculations of SU (2)-gauged scalar field theories in particle and condensed matter physics

Ref. BLTW22007

PI: Alberto Ramos Martínez  
23,607 € (Jan 2023 – Dec 2024)

- Optimización de las búsquedas de la producción de pares de bosones del Higgs en el experimento ATLAS del LHC

Ref. 20235PRC04

PI: Nuria Rius Dionis  
120,000 € (Apr 2023 – Apr 2025)

- Protón: Proceso de Evaluación tomográfica de Residuos Nucleares

Ref. SUB-2/2023 (CSN)

PI: Francisco J. Albiol Colomer  
97,028 € (Dec 2023 – Dec 2025)

- Podcast de Física del IFIC

Ref. 16756

PI: Enrique Nacher González  
18,000 € (Jan 2022 – Dec 2023)

- Proyecto Meitner. Recordando a Lise Meitner

Ref. 16806

PI: Angela Molina Ruiz  
25,000 € (Jul 2022 – Jun 2023)

## CONTRACTS AND AGREEMENTS

- Sentiment Analysis para el Grupo Martínez con Inteligencia Artificial (SMartIA)

Ref. 20230245

PI: Byan Zaldivar Montero  
3,306 € (Jan 2023 – Apr 2023)

- Desarrollo de un detector compacto de neutrones y rayos gamma

Ref. 20231396

PI: Luis Caballero Ontanaya  
54,450 € (Jan 2023 – Jul 2025)

- CERN-ISOLDE-HISTARS

Ref. Fondos MRR Experimentos CERN

PI: Enrique Nacher González  
221,000 € (Jul 2023 – Dec 2025)

- CERN-ATLAS

Ref. Fondos MRR Experimentos CERN

PI: Carlos Lacasta Llacer  
600,000 € (Jul 2023 – Dec 2025)

- Gestion MRR

Ref. Fondos MRR Experimentos CERN

PI: Carlos Lacasta Llacer  
90,000 € (Jul 2023 – Dec 2025)

- CERN-n\_TOF

Ref. Fondos MRR Experimentos CERN

PI: César Domingo Pardo  
546,000 € (Jul 2023 – Dec 2025)

- CERN-LHCb

Ref. Fondos MRR Experimentos CERN

PI: Fernando Martinez Vidal  
1,083,000 € (Jul 2023 – Dec 2025)

- Convenio entre la AE CSIC y ENRESA:

Imagen Gamma: Implementacion de nuevos desarrollos e integracion con dispositivos empleados por ENRESA

Ref. 20235526

PI: Francisco J. Albiol Colomer  
593,389 € (Jul 2023 – Jul 2028)

- Desarrollo de equipos PET de alta cobertura de uso clínico

Ref. 20213188

PI: Gabriela Llosá Llácer  
80,000 € (May 2021 – Sep 2023)

- Diseño mecánico y adecuación de sistemas de gas y frío de un prototipo de tomógrafo PET basado en xenón líquido

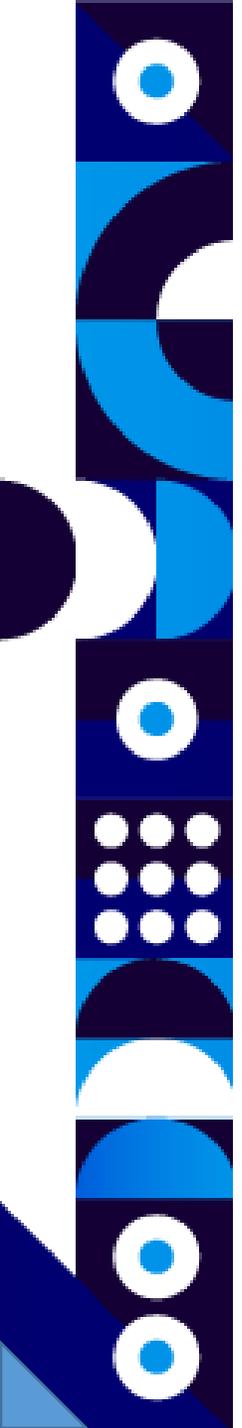
Ref. IMAS

PI: Neus López March  
90,800 € (May 2021 – Sep 2023)

- Contrato de licencia exclusiva de la patente 201231243 "Dispositivo y procedimiento de obtención de imágenes densitométricas de objetos mediante combinación de sistemas radiológicos"

Ref. 20132089

PI: Germán Rodrigo García  
6,171 € (May 2013 – Jul 2032)



## Images and vectors references

[www.freepik.es](http://www.freepik.es), [www.pixabay.com](http://www.pixabay.com), <https://www.flaticon.es/autores/darius-dan>, [www.pexels.com](http://www.pexels.com)